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CATALOGUE  
OF THE  
MADREPORARIAN CORALS  
IN THE  
BRITISH MUSEUM  
(NATURAL HISTORY).

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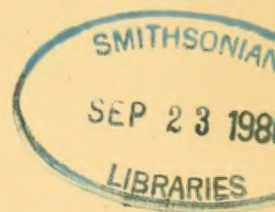
VOLUME II.  
THE GENUS TURBINARIA,  
THE GENUS ASTRÆOPORA.

BY  
HENRY M. BERNARD,  
M.A. CANTAB., F.L.S., F.Z.S.

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## P R E F A C E.

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THE publication of the Catalogue of Madreporarian Corals, which was undertaken by Mr. George Brook, and of which the first part appeared in 1893, was, unhappily, interrupted by the premature and much-lamented death of that accomplished zoologist.

In this emergency, Dr. Günther, then Keeper of the Zoological Department, was fortunately able to engage the services of Mr. H. M. Bernard, by whom the present volume has been prepared. The Collection has continued to increase, and the specimens recently obtained in expeditions to coral-bearing seas, undertaken by Professor A. C. Haddon, Mr. J. J. Lister, and especially Mr. W. Saville-Kent, combined with those already in the Museum, have resulted in the incomparable series of the genera *Turbinaria* and *Astræopora* described in this volume.

As in the case of the first volume the author's photographs have been reproduced by the collotype process, the work having been executed with great care by Messrs. Morgan and Kidd, of Richmond, Surrey. Three lithographed plates by M. Berjeau have also been added in order to show the microscopic details referred to in the text, which the collotype process is not adapted to reproduce.



Mr. F. Jeffrey Bell, the member of the permanent Museum staff who has charge of this section of the Collection, has rendered every assistance to Mr. Bernard throughout the progress of the work, both in its preliminary stages and while passing through the press.

W. H. FLOWER,  
*Director.*

*British Museum (Natural History),  
March 1896.*

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# CATALOGUE

OF

## MADREPORARIA.

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### VOLUME II.

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### TURBINARIA.

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#### INTRODUCTORY.

THIS interesting genus of Stony Corals is remarkably rich in forms—cups, large and small; globular masses; great, shapeless mounds; immense cabbage-like growths of erect leaves, curling or flat; low, creeping forms, sending up hollow cylinders or tangles of small crisp leaflets; and many other equally beautiful and striking growths.

The name *Turbinaria* (Turbo, a whirl, a top) was originally applied to the cup-shaped specimens alone. It was only little by little that the other growths of this coral, though so unlike cups, and bearing other names, were found to be related forms, and came to be classed under the same name. In so grouping them together, naturalists were led chiefly by the apparent stolon-like method of budding of the polyps, common to them all. Time has fully justified this arrangement, and thrown light upon this peculiar method of budding. Any large collection, such as that in the British Museum, will be found to contain so many cups, and so many cups which, by the frilling or drooping of their edges, are in the process of changing into one or other of the above-mentioned growths—and further, so many forms, now no longer like cups, but which, on closer scrutiny, show that they were at one time stalked—that one is forced to the conclusion that they all began life as minute cups, and only as they grew in size lost the cup shape. It is, however, not always lost, for some continue to grow as cups to an enormous size.

The genus *Turbinaria*, therefore, is remarkable on this very account. It stands alone among the other genera of Stony Corals by its singular start in life. The first polyp of a colony, developing from an attached larva, grows to a certain height before it buds. When



the buds appear, they form a definite ring around their parent, some way above the surface of attachment. This ring of buds then itself buds again, and always in such a way that the parent polyp forms a stalk, while the successive generations of daughters around it form an expanded cup or plate on the top of it. The epithecal floor on which the parent polyp arose, and which, I am convinced, plays an important part in the formation of coral skeletons, in this case drops out; the whole cup is built up entirely of the septa and their synapticular connections. This young cup or plate, always budding round its edge, may either, as will be more minutely described in the following pages, continue the cup form, or sooner or later lose it beyond all further recognition by the folding and frilling of the edges.

The recognition of this peculiar method of growth of the genus *Turbinaria* removes it from close kinship with any other genus of Stony Coral. Its probable relationship to the genus *Madrepora* will, however, be briefly indicated in the following pages.

At the end of the volume will be found thirty plates (collotyped reproductions of photographs), revealing some of the more important methods of growth of *Turbinaria* and *Astræopora*, and, in a few cases, series showing the development of Turbinarians from their initial cups. In preparing the original photographs of the specimens I have been greatly indebted to the industry and technical skill of Mr. RICHARDS, attendant in the Zoological Department, to whom my best thanks are due, and are here cordially tendered. The collotype plates are followed by three plates, giving enlarged lithographed drawings, to show, in surface view, the finer structure of the skeleton immediately surrounding the polyp cavities.

The work of classifying the specimens, at all times arduous, but especially so in the case of such a highly variable group as the Corals, has been throughout materially lightened for me by the sympathy and encouragement which I invariably received from the late Keeper of the Zoological Department, Dr. GÜNTHER, under whose auspices I first undertook to describe the rich and ever-growing collections in the Museum, of which it is hardly an exaggeration to say that the greater part are practically new to science. I take this opportunity of recording the debt of gratitude which I owe to Dr. GÜNTHER. My sincerest thanks are also due to Professor JEFFREY BELL, not only for the great pains he has taken in editing my MS., but also for many very valuable hints and suggestions as to the treatment of the subject. He has, also, at all times generously accorded me all the assistance in his power in the section of the Museum of which he has more immediate oversight.

#### HISTORICAL.

The name *Turbinaria* was given by Oken,\* in 1815, to the third genus of his Gypskorallen. His somewhat quaint description is of very limited application, and must have been suggested by small specimens; indeed, he gives the size from "handgross bis 1'." The corallum consists, according to Oken, of tubes branching out from a common stem, like

\* 'Lehrbuch der Naturgeschichte,' Zool. i. p. 65.



the flowers of an umbelliferous plant, all being firmly cemented together by a substance which forms the general surface. On this surface all the tubes open at about the same level. Oken's principal species is *Turbinaria* (*Madrepora*) *crater* of Pallas, but he included also *Madrepora pellata*, *M. cinerascens*, Ellis and Solander; and, further, *M. pilcus*, figured by Ellis and Solander, and now known as *Herpetolithes limacinus*, and very widely removed from the Turbinarians.

This description is of more than mere historical interest, inasmuch as it faintly recognises the arrangement of the polyps as giving the form to the coral. But, for lack of workers, no one recognised that the specimens so described were merely the early stages in the growth of an important genus containing many large and imposing forms.

About the same time (1816), Lamarck\* divided his Polypiers lamellifères into those with terminal corallites and those with corallites arranged laterally or spread out over a surface. This latter division is again divided into those with corallites on one side and those with confluent corallites on all sides. Under the former heading are arranged three genera: *Echinopora*, *Explanaria* and *Astrea*. In this classification of Lamarck we again find some faint recognition of the mutual relationship of the individual corallites as the leading principle. It is, however, vague and unsatisfactory, and finds no place in his definition of the genus.† The very different generic names and descriptions given by Lamarck ("*Explanaria*") and Oken ("*Turbinaria*") suggest that whereas the latter had chiefly, if not exclusively, young cup-shaped specimens, Lamarck had much larger specimens in which the cup form was more or less obscured by the membranous fronds.

Under the genus *Explanaria*, Lamarck, ignoring or ignorant of Oken's genus *Turbinaria*, grouped the *Madrepora crater* of Pallas, re-named *Explanaria infundibulum*, with Ellis and Solander's species *M. cinerascens*. This, in describing a specimen which he took to be the same species, he practically re-named *Explanaria mesenterina*. With these two, he associated four other species which are not Turbinarians. Two true Turbinarians, however, *T. palifera* and *T. stellulata*, were included among his *Astrea* under the same specific names. Further, *mesenterina*, after being long used as a synonym for *cinerascens*, subsequently became a separate species.

In 1820, Schweigger‡ adopted Lamarck's *Explanaria* under the following definition, "*Stirps superne dilatata, margine subfoliaceo, basi contracta, tubulis lamellosis in massa calcarca sparsis et parallelis, apicibus emergentibus*," but gives only two species, *Explanaria crater* and *Ex. cinerascens*. Schweigger thus, while adopting Lamarck's generic name, returned to the older specific names, rejecting Lamarck's names *infundibulum* and *mesenterina*.

Eichwald, in 1829 ('*Zoologia specialis*,' i. p. 184), follows Lamarck and Schweigger with

\* 'Hist. Nat. des Animaux sans Vertèbres,' ii. pp. 220, 254.

† "Polyparium lapideum, fixum, in membranam liberam, foliaceam, undatam aut convolutam et sublobatam expansum; una superficie stellifera. Stellæ sparsæ, sessiles, subdistinctæ."—p. 254.

‡ 'Handbuch der Naturgeschichte der skelettlosen ungegliederten Thiere,' p. 419.



hardly any alteration. The genus contains the same two species, with, however, another shuffle of the specific names, viz. *Ex. infundibulum* and *Ex. cinerascens*.

In 1830, De Blainville\* rearranged the Stony Corals, and, recognising the fact that Lamarck had included in his *Explanaria* forms which were generically distinct, he rejected the name "*Explanaria*" as being too indefinite, preferring *Gemmipora*—in reference to the protruding bud-like calicles. He selected the two true Turbinarians, viz. *Explanaria crater* and *Ex. mesenterina*, once more shuffling the specific names, and united with them the *Madrepora peltata* of Esper and his own *Gemmipora fungiformis*. These together formed a division of a new genus, *Gemmipora*. The division is "explaniform, and with cells only on one side," in contrast to two other extant divisions:—

(1) Arborescent: with cells on all sides, containing one species, *G. abrotonoidea*, which I have been unable to trace further, unless it be identical with the *Madrepora abrotonoides*, in which case he classified the same coral under two different heads ('Manuel d'Actinologie,' p. 387, under *Gemmipora*; and p. 390, under *Madrepora*).

(2) Encrusting: founded on Lamarck's *Astræa palifera*, which became *Gemmipora palifera*, and persists as *Turbinaria palifera*, M.-E. and H.†

Of this arrangement, *G. crater*, *G. mesenterina*, *G. peltata*, *G. palifera* and (?) *G. fungiformis*, persist under the changed generic name.

It is worth noting that Blainville completely ignores Oken's *Turbinaria*. This is the more remarkable because the type of his own species, *G. fungiformis*, which was a small stalked disc, might have reminded him of Oken's general description of his Turbinarians. Perhaps, as was probably the case with Lamarck, having larger specimens to deal with, he thought Oken's description too fanciful. He clearly never discovered that Oken's genus *Turbinaria* described the young stages of his own genus *Gemmipora*.

With regard to Blainville's principle of classification, he (p. 332) claims to base it on the character of the animals themselves, taken together with their coralla. Owing, however, to the imperfection of our knowledge of the animals, this resolves itself practically into a comparison of the cells, as apart from the form of the corallum, or the distribution of the polyps on its surface. Hence the name *Gemmipora*,‡ which called attention to the bud-like cells, and was therefore thought preferable to Lamarck's *Explanaria*, which referred chiefly to the form of the corallum.

In 1834, Ehrenberg published his classical work on the coral-animals of the Red Sea.§

\* Dict. d. Sci. Nat., lx. pp. 352-3; repeated (1834) in his 'Manuel,' p. 387.

† In addition, Blainville gives one fossil form, *G. cyathiformis*, which has been accepted by Milne-Edwards and Haime as *Turbinaria cyathiformis*.

‡ "Animaux inconnus, contenus dans des loges profondes, cylindriques, cannelées, et presque lamelleuses à l'intérieur, saillantes en forme de bouton, et éparses assez régulièrement à la surface d'un polypier calcaire, fixe, poreux, arborescent ou développé en grande lame plus ou moins ondulée et pédiculée."—p. 387.

§ 'Beiträge zur Kenntniss der Corallenthier der rothen Meeres.'

His 49th genus is *Turbinaria* of Oken, which comprised the "*Explanaria*, Lamk. ex parte, and *Gemmipora*, Blainville." And his 50th genus is *Explanaria*, Lamk.

The guiding principle in this rearrangement was clearly to keep the genus *Turbinaria* for the smaller, more regularly cup-shaped coralla, while *Explanaria* contained the larger membranous corals, in which, if any of them were *Turbinariæ*, the cup shape was obscured or obliterated. This can be gathered from his definitions. In the former case the corallum is described as stalked, in the latter there is said to be no stalk.

In his genus *Turbinaria* he has three species: *T. cupula*, *T. peltata*, and *T. microstoma*. How completely he was in the dark as to the transitory nature of the cup form, may be gathered from the fact that a specimen (or specimens) of his *T. cupula*, showing folding of the margin, became a variety, *T. plicatula*.

Ehrenberg failed to identify any of his specimens with the *T. crater* of Pallas; and *T. cinerascens* he referred to the genus *Explanaria*. Dana has suggested that Ehrenberg's *T. cupula* is the same as his own (Esper's) *peltata*, and Ehrenberg's *peltata* is the same as Dana's *patula*; this suggestion seems to have been generally adopted. But, in view of the fact that the species of *Turbinaria* are far more numerous than Dana was at all aware of, it is quite as probable that Ehrenberg's Red Sea Turbinarians were distinct.

Of the seven species of his *Explanaria*, only one appears to be a true Turbinarian, viz. *T. cinerascens*. This, from the description, appears to be the true *T. mesenterina*.

With regard to his system of classification of corals, Ehrenberg lays it down as a principle that, the corallum being a product of the fission, budding, or stolon-formation of individual coral animals, the method of reproduction is of prime importance.

Accordingly, in his definitions of the genera, he describes the various methods of budding or stolon-formation in each case. We have, therefore, descriptions of the budding of his genus *Turbinaria* (=young cup-shaped Turbinarians) and of his genus *Explanaria* (=older specimens in which, when Turbinarians, the cup is obscured).

His account of the budding in "*Turbinaria*" is somewhat different to that already given by Oken. It is not easy now to understand exactly what he meant. The description runs as follows: "*The stars send out stolons laterally in all directions. There is no ordinary budding except abnormally. The stolons, joined together, rise freely from the substratum. There is a common base, forming a stalk; the form is accordingly circular, and often cup-shaped.*"\* And further on he adds, that "*the Turbinariæ are not necessarily concave.*"

It is clear, from this description, that Ehrenberg had not recognised the true method of budding peculiar to the genus. That he did not mean the axial polyps in the stalks of different cups by "*the stars which send out the stolons*" follows from his repeating the same words in his description of the genus "*Explanaria*," which, according to him, has no

\* The Latin, of which the above is a free rendering, is as follows: "*Stellis proliferis, undique a latere (oblique) stoloniferis, nec mere gemmascentibus nisi monstruose, nec dividuis, stolonibus conjunctim libere ascendentibus, basi communi, in stipitem pallio semper obductum clata, stirpe extus sterili (hinc orbiculares et sæpe cupuliformes).*"



stalk, and hence would have no axial polyp. In this respect Oken, whose comparison of the arrangement of the polyps of *Turbinaria* to the inflorescence of an umbelliferous plant suggests an axial polyp, came nearer the truth. Ehrenberg's statement that there is no ordinary budding except abnormally is meant especially to emphasise the fact that the polyps reproduce by "stolon-formation." This erroneous description of the method of budding has been repeated by subsequent observers, and was only recently corrected by the present writer. It cannot, however, detract from the honour due to this great naturalist for insisting upon giving to the method of reproduction its true value in the classification of the Corals.

In 1848 appeared Dana's magnificent work on the 'Zoophytes of the United States' Exploring Expedition during the years 1838-42.' Dana proposed a classification of the Zoophytes based upon the number and arrangement of the tentacles of the living animals, and, like Ehrenberg, on the methods of reproduction.

In his first division, the *Astræacea*, the gemmation is superior, and the oral discs divide. In the second, *Caryophyllacea*, the gemmation is inferior. In the third, *Madreporeacea*, the gemmation is lateral. In the third family of the *Caryophyllacea* (in which the gemmation is inferior) Dana placed the *Gemmiporidae*, including two genera, *Gemmipora* and "*Astracopora*.(?)" The genus *Gemmipora* is synonymous with Oken's *Turbinaria*, which name, in spite of its priority, Dana rejected, because of its liability to be confused with Lamarck's genus "*Turbinolia*" (= *Turbinolia*); and further, because Oken introduced his name "without reference to the previously-formed genera of Lamarck." It may be remarked, however, that Lamarck's genus *Explanaria* first appeared in the second volume of his 'Histoire Naturelle des Animaux sans Vertèbres,' in 1816, the year after Oken's name appeared. The genus was not made in Lamarck's earlier publications, referred to by Dana, viz. the 'Système des Animaux sans Vertèbres,' 1801, and the 'Extrait du Cours de Zoologie du Mus. d'Histoire Nat. des Animaux sans Vert.,' 1812.

Dana's genus contains seven species, of which four were already established—*peltata*, *crater*, *cinerascens*, and *palifera*; the three new ones were *patula*, *frondens* and *brassica*. Lamarck's *mesenterina* and Ehrenberg's *cupula* and *microstoma* are quoted as synonyms.

We here find Dana recognising the relations of the individual corallites as one of the leading principles of his classification. But his division of the species into three groups—(1) glomerate; (2) explanate, from a central pedicel; (3) foliaceous, with the folia clustered—shows that he did not recognise the fact that all *Turbinariæ* are typically stalked at their earliest stages, owing to their peculiar method of budding. The section which he gives of a *Gemmiporan* ('Zoophytes,' fig. 27, p. 67) is only that of a portion of a frond, in which at first sight the budding looks as if it were lateral-inferior, as he describes it. Dana thus practically repeated Ehrenberg's "stolon-formation." The error is very natural, inasmuch as it is not easy to see how, without following the process of budding from the axial polyp in the young stalked cup, any one could have recognised the true type of budding from the section through a frond.

One unfortunate result of this error was to compel Dana to divorce *Gemmipora* entirely

from *Madrepora*; the former having, according to him, basal, and the other lateral budding, whereas the budding is in both cases lateral. On the other hand, he was clearly not quite satisfied with the association of *Gemmipora* and *Astræopora* in one family, as is shown by the note of interrogation which is placed after the latter.

During the years 1848-51, H. Milne-Edwards and J. Haime developed, in a series of classical works, a new system of classification of the Stony Corals, on which was founded their great systematic work 'Les Coralliaires' (vols. i. and ii., 1857; vol. iii., by Milne-Edwards alone, 1860). They were unable to follow Ehrenberg and Dana, in laying chief stress upon the methods of grouping of the individual corallites forming a corallum, or, in other words, upon the method of budding. They preferred to base their classification upon the structural characteristics of the individual polyps, as seen in their skeletal remains, which alone, in the majority of cases, we have at our disposal for investigation (vol. ii. p. 4). According to this, they divided the Stony Corals into five groups, the two principal being the Madreporaria imperforata or aporosa, and the Madreporaria perforata, according as the skeletal framework (sclerenchyme) is compact or perforated.

According, then, to the classification of H. Milne-Edwards and Haime, the first division of the perforate Madreporaria is the Madreporidæ, which, again, is divided into three sub-families—Eupsamminæ, Madreporinæ and Turbinariinæ. The last-named is distinguished from the Madreporinæ by the absence of the two (directive) septa conspicuously larger than the rest.\* The Turbinariinæ fall into five genera, of which *Turbinaria* and *Astræopora* are those alone which can here concern us, the other three being fossil. The Turbinarians are said to be distinguished from the Astreoporans by the presence of a well-developed spongy columella. In the genus *Turbinaria*, all Dana's species are adopted (but *frondens* is called *frondescens*, apparently by a clerical error). In addition, we find Lamarck's *mesenterina* recognised as a distinct species from *cinerascens*, and Blainville's *Astreopora stellulata* (*Astræa stellulata*, Lamk.) suggested as a true Turbinarian.

While, however, Milne-Edwards follows Ehrenberg in reviving Oken's genus *Turbinaria*, combining with it part of Lamarck's *Explanaria*, he makes no mention either of Oken's "doldenförmig" arrangement of the polyps, or of Ehrenberg's description of the growth of the corallum by stolon-formation as apart from ordinary budding. It is true that he mentions the method of growth which can be "very easily" ('Les Coralliaires,' i. p. 85) gathered from a section of a corallum, meaning evidently from the section of a frond. But, in his definition of the genus, he omits all mention of it.

Verrill, in 1865,† proposed a classification of the corals in which the genus *Turbinaria* belongs to the family Gemmiporidæ, of the suborder Madreporaceæ (Madreporaria perforata of Milne-Edwards), the order being Madreporaria, which, with two other orders—the Actinaria and the Alecyonaria, of equal value—embrace the whole class of the Zoophytes. Beyond

\* This distinction, however, does not hold good, directive septa being found in some species of *Turbinaria*.

† 'Proceedings of the Essex Institute,' iv. p. 145.



describing two new species, *T. sinensis* and *T. dichotoma*, he adds no new observations on the morphology or affinities of the genus.

Klunzinger, in 1879, in an important work ('Die Korallenthier des rothen Meeres') adopts Verrill's position for the genus *Turbinaria*, changing, however, the family name into Turbinaridæ, which comprises two genera, *Turbinaria* and *Astræopora*. Following earlier authors, he describes the method of budding as basal. He does not, however, repeat Dana's doubts as to the association of *Astræopora* with *Turbinaria* in one family.

Besides giving a detailed description of Lamarck's species, *T. mesenterina*, he records one new species, *T. conica*, his description being illustrated by photographs.

In 1880, Professor Studer,\* following Ehrenberg and Dana, described the budding of *Turbinaria* as basal. The young buds are said to appear in a "basal expansion of the cœnenchyma, somewhat as in *Galaxea*."

In 1884, Professor Martin Duncan† revised Milne-Edwards' classification of the families and genera of the Madreporaria. No alteration was, however, made in the position and affinities of the genus *Turbinaria*.

In 1886, Mr. Quelch, in his 'Challenger' report on the Reef Corals, while in the main following Martin Duncan's revised classification, greatly simplified it. Under the family Madreporidæ, he simply ranges five genera: *Turbinaria*, *Madrepora*, *Astræopora*, *Anæropora* and *Montipora*. He distributed the specimens of *Turbinaria* collected by the 'Challenger' among seven species, of which one, *T. aqualis*, is new.

In still more recent times, great attention has been paid to the anatomy, morphology and development of the individual polyps, studied by means of the more exact methods of research now common in our laboratories. These investigations are, however, not extensive enough, and the investigators are not sufficiently unanimous in their interpretations, to admit of more than suggestions as to the guiding principles of a natural classification. They further appear to leave out of account the influences arising from the form of the colony upon the individual polyps, which, in some cases,‡ at least, are, I am convinced, considerable.

In 1888, Mr. G. C. Bourne§ suggested an entire rearrangement of the Madreporaria, based upon the morphology of the polyp. The Madreporaria fall into four groups: (1) with no directive mesenteries and a perfectly radial symmetry; (2)—in which the genus *Turbinaria* falls—with directive mesenteries and a combined radial and bilateral symmetry; (3) with reduced radial and marked bilateral symmetry; (4) with basal pseudotheca and no "Randplatte."

\* 'Über Knospung und Theilung bei Madreporariern,' Mitth. Nat. Forsch. Gesell. Bern, 1880, p. 6.

† Linnean Soc. Journ. Zool., vol. xviii. p. 1.

‡ 'Notes, Morphological and Systematic, on the genus *Turbinaria*,' Ann. and Mag. Nat. Hist., xv. (1895) p. 518.

§ Quart. Journ. Micro. Sci., xxviii. p. 49.

In 1889,\* and in 1890,† Dr. Ortmann proposed two principles of classification. The former is based upon the type of the skeleton of the individual corallites, the corals falling under this heading into three groups: Euthecalia, Pseudothecalia and Athecalia. The second is based upon the method of budding which gives rise to the form of the corallum characteristic of each genus. The Madreporidæ (including *Turbinaria*) are classified as follows: order Athecalia, suborder Synapticulata, the septa being connected by a wall-like arrangement of synapticulæ. Colonies formed by "Wandknospung," or lateral budding from the wall, the porous wall in all cases being secondarily thickened.‡ Dr. Ortmann, further, gives a provisional phylogenetic tree, in which *Turbinaria* is derived from *Astræopora*. He adds two new species: *T. maxima* and *T. quincuncialis*.

In 1892, Rehberg,§ in describing the corals of the Hamburg Museum, records two new species, *T. marmora* and *T. crispa*.

In the autumn of 1894, the present writer made a special study of the genus, basing his researches upon the specimens in the British Museum, which had been enriched by the great collections made by Mr. Saville-Kent on the Great Barrier Reef, as well as on the west coast of Australia.|| The results obtained by the author, briefly sketched above in the introductory paragraphs, are described in more detail in the following pages.¶

#### THE LIVING POLYP AND ITS ANATOMY.

Dana, in the atlas to his 'Zoophytes,' gives pictures of the living animals of *T. frondens* (pl. xxvii. 10a), *T. palifera* (pl. xxix. 2b), and of *T. peltata* (pl. xxx. 4a). The tentacles in these figures are all more or less contracted. Saville-Kent\*\* has recently given coloured figures of living Turbinarian polyps, viz. of *T. patula*, *T. peltata* and *T. "cinerascens,"* with expanded tentacles. These latter are pointed, awl-shaped, and appear to be somewhat longer than the diameter of the oral disc.

The colours appear to be very brilliant and to show great variations. Dana, for instance, figures *T. peltata* pale green, with a blue oral disc. Saville-Kent described the colours as being, in some cases, white with greenish centres on a whitish brown corallum, which is described as "thickly studded inside with short-stalked daisies"; other specimens occurred in which corallum and polyp are a delicate rose pink.

\* Zool. Jahrb. Syst. Abth., iv. p. 493.

† Zeitsch. wiss. Zool., i. p. 278.

‡ This is not the place to enter into a lengthy criticism of this scheme. Its applicability to this genus will be explained in the section on Morphology, p. 10.

§ Abh. Nat. Wiss. Ver. Hamburg, xii. p. 1.

|| Two smaller collections, one made by Mr. J. J. Lister at Tongatabu, and the second by Professor A. C. Haddon in the Torres Straits, were incorporated about the same time.

¶ Cf. also Ann. and Mag. Nat. Hist., (6) xv. (1895) p. 499.

\*\* See chrom. pl. viii. in 'The Great Barrier Reef.'



The only paper which I have found dealing with the anatomy of a Turbinarian is by Dr. G. Herbert Fowler.\*

A fragment, belonging "apparently to the type *T. mesenterina*," showed that (1) the polyps are of the normal Actinian type, are bilateral, the axial and abaxial directive mesenteries being placed approximately in a plane running at right angles to the growing edge of the corallum. These are distinguished by the arrangement of retractor muscles on their ectocœlic faces. The polyps, however, are not rigidly bisymmetrical, inasmuch as the pairs of mesenteries lying right and left of the dividing plane are not equal in number.

(2) The septa are entocœlic only, although a misleading appearance of ectocœlic septa is produced by the fact that some pairs of mesenteries die out after a very short course, while their septa are still recognisable at a much greater depth in the polyp-cavity.

(3) The tentacles are probably entocœlic only. In the contracted condition, they are covered by a ring-fold formed of the indrawn margins of the disc.

(4) The whole colony, both inside and outside, is clothed with an external body-wall of ectoderm; this wall rests upon the echinulations of the cœnenchyma.

(5) Nematocysts are closely packed together in the tentacles, not, however, arranged in knobs or "batteries."

(6) Zooxanthellæ are present abundantly in the canals exterior to the theca, in the tentacle-cavities, and immediately under the mouth-disc; elsewhere they are comparatively rare.

### MORPHOLOGICAL.

#### *Description and Definition of the Genus based upon the Examination of the Hard Parts.*

*Rise and Growth of the Corallum.*—The earliest known stage in the development of *Turbinaria* is typically a minute cup. This form is apparently the natural result of the method of budding of the original parent polyp, and of the secondary budding of these buds.

A cross-section through the stem of a young cup shows a large central polyp, which is that of the parent polyp of the colony. This is surrounded by a great thickness of light spongy cœnenchyma forming the main support of the cup. This layer may be described as built up of long, radiating, perforated costæ (which continue very irregularly the radiation of the septa), bound together by tangential trabeculæ.

From this original polyp, a single ring of new polyps bud laterally, either at or near the same level. These buds grow out at an angle from the original parent polyp, which then appears itself to die down; in no case does it continue to grow like the axial polyp in *Madrepora*, budding forth successive rings of daughter polyps. As stated, the axial parent polyp in *Turbinaria* appears to die down, and the colony is carried on exclusively by the ring of daughter (and sometimes at least smaller) polyps. These, again, develop buds on the side

\* 'Anatomy of the Madreporaria,' pt. iii. Quart. Journ. Micro. Sci., xxviii. p. 1.

turned away from the axial parent polyp. These buds of the second generation probably form parts of rings round *their* parents.

Each polyp of the successive generations, after growing out radially for a certain distance, bends up so that its aperture either looks up or faces the axis of the cup, according to the angle at which the first ring of buds leaves the sides of the parent polyp. It is obvious that, but for this bend upwards of each generation of polyps, the successive generations, budding at an angle to their parents away from the axis of the cup, would soon cause the edge of the corallum to curl round against the stalk of the cup. As it is, indeed, the early cup often becomes a creeping or encrusting form, when the angle at which the buds leave their parents is large. Typically, however, the method of budding thus described leads to the formation of a cup which will be deep and conical, or flat and shallow, according as the budding polyps slope upwards at a smaller or larger angle to the axis.

The outline of the rim of the young cup will, again, be perfectly regular if the buds of the first ring develop at the same level; but if at different levels, then the rim of the young cup will follow the line formed by the buds round the central polyp.

This central axial polyp is seldom, if ever, recognisable in the base even of the youngest cup. It appears very early either to die down, or to be completely submerged by the cœnenchyma. This submergence of polyps is seen throughout the Turbinarians. The downward flow of nutrient matter, which is ever adding the necessary thickness to the stalk outside, fills up the inside of the cup so fast that the polyps are (with some exceptions) unable to keep pace with the growth in thickness of the cœnenchyma, and are, as a rule, found immersed, often altogether obliterated. This I believe to be the usual fate of the central polyp. We may note that the downward flow of the nutrient fluids from the polyps round the axial polyp of a Madrepora, in thickening the wall of the latter, typically submerges the earliest formed and lowest buds.

Although, as a rule, each Turbinarian polyp only buds in the definite ways above described, when submerged by cœnenchyma, and also in thick glomerate forms, it may put out fresh buds, which open on the rising surface of the cœnenchyma. Thus, while typically young calices are only found at the growing edges of the corallum, they may also occur in patches (Plate XVIII.) at other parts of its upper surface (cf. Ehrenberg's words, "*nee mere gemmascentibus nisi monstruosè*").

*The Epitheca.*—The basal plate upon which the axial polyp develops is left behind, and seems merely to form a cementing substance between the stalk and the substratum. A secondary epitheca may, however, appear on the under sides of fronds, especially where they tend to touch the substratum. It is obvious, therefore, that the Turbinarians are purely cœnenchymatous corals. The skeleton of the axial polyp is built up entirely of the septa, and their synapticular connections, forming together the cœnenchymatous wall of the polyp. Out of this wall, and without any connection with the epitheca, the buds develop. The epitheca has, in fact, dropped out of the skeleton in all its subsequent developments, except where a secondary appearance of it takes place, as above stated. The whole corallum is built



up of the porous cœnenchymatous walls of the individual polyps, without any trace of epithelial envelopes, or of regular "thecæ."\* Hence the application of the term Athecalia.

*The Growth of the Corallum.*—We have, then, these two principal factors to account for the special forms of the Turbinarians: (1) the peculiar method of budding, and (2) the gravitation of the fluids thickening the cœnenchyma. All or most of the forms which the genus assumes can be traced to the varying action of these two.

A great number of the alterations in the shape of the early cup are due to the folding or frilling of the edge. This, it seems, would follow almost as a necessity from the method of budding. As the circumference of a young cup increases, the distance between any two adjacent radially-developing polyps also increases. Any slight excess of growth in any pair of polyps, before their buds were given off on their under or outer surfaces, would, by increasing the space between them, allow a slightly more complete ring of buds to appear; they would not be *entirely* confined to the under and outer surface. It is obvious that any appearance of buds *above* (however slightly) the level of the plane passing through the axes of their parent polyps, must lead to folding of the edge, that is, to an upward folding. A downward folding might occur at any time by the increase in the angle at which the buds leave their parent polyp. By the increase of this angle, also, a corallum which began as a stalked cup might change into an encrusting form.

With regard to the changes brought about by the downward streaming of the cœnenchyma, we have already mentioned the thickening of the stalk of the cup which may even be obliterated, and to the gradual filling up of the base of the cup inside. In the same way valleys are filled up and fronds thickened. This downward streaming, moreover, leaves unmistakable signs in the surface markings of the cœnenchyma. The very characteristic longitudinal striation on the outer side of the cup, noticed by nearly all those who have described the Turbinarians, indicates the direction of the superficial canal system. This striation, or channelling, of the surface is also well marked on the inner side of deep cups; it indicates the downward streaming which leads to the filling up of the bottom of the cup already described. There are no such channels near the growing edge of the cup, nor in any instance where the fluids are required to build up the cœnenchyma *in situ*. In these cases the cœnenchyma is *always* spongy.

The Turbinarians form no exception to the rule of progressive dying down of the basal regions as the corallum grows. But this is often greatly disguised by the flowings of the cœnenchyma above described; downward streamings of living cœnenchyma, often producing polyps, not only submerge living polyps, but overrun the dead basal portions of the corallum. The fixation of successive layers of these downward streamings at different heights gives many coralla a remarkable appearance, as if there had been alternate periods of growth and decay. But although the Turbinarians, as a whole, conform to the rule of progressive growth, with

\* Whether any essential morphological distinction exists between the regular circular "theca," and the irregular synapticular connections between the septa, I cannot here decide. The distinction is of practical utility.

accompanying decay of the basal portions, there are cases which look like a true periodicity in the growth, e. g. in many tabulate forms (see below, on Types of Growth).

*The Polyp-cavities or Calicles.\**—Confining ourselves to those points which are characteristic of the genus, we find the calicles separated by an intervening mass of porous cœnenchyma. Into this they may either be sunk, or from it they may project above the surface, in which case they carry up the cœnenchyma with them in various thicknesses, and at varying slopes. These differences are of systematic value, and will be described in the section dealing with the principles of classification adopted in this Catalogue.

The apertures vary from round to oval, being sometimes almost oblong. There is no very marked differentiation of the septa; although different cycles can occasionally be traced in the slight variations in size, and also in the fact that the numbers generally range near some multiple of 6—viz. 12, 18, 24, and further directives are here and there recognisable. When the aperture is oval or oblong, the septa are usually modified, being shortened and sometimes confluent at the corners. In round calicles, the septa are usually very uniform.

At varying depths in the calicles the septa meet to form a columella, which may rise in the base of the calicle as a protuberance free of the septa. It is probable that the formation of this columella is an adaptation for the purpose of strengthening the often thin margin of the corallum, which would be far more fragile if perforated by so large a number of open pits. As the corallum thickens, the polyp-cavities have to lengthen to keep pace, if possible, with the rising surface of cœnenchyma. As a rule, in such cases the columella grows continuously upwards, but occasionally it is discontinuous (specimens of *T. peltata*).

The septa within the calicles are not infrequently associated with the ridges on the cœnenchyma, and it is impossible to avoid the conclusion, that at one time these ridges were the developments of true costæ. In many calicles the septa show a tendency to twist spirally, and in protuberant calicles the ridges of cœnenchyma on their walls, in many cases, show the same. A similar spiral twist can be observed in the costæ of protuberant calicles in true Madreporæ.

*Definition of the genus Turbinaria.*—Madreporaria developing from a parent axial polyp, round which a ring of buds arise above it, free from the basal epitheca in such a way that the first stage of growth forms a stalked cup or plate, with the polyp-cavities opening on its inner or upper face. Growth is continued by this ring of buds, which bud again in their turn on their outer or under sides, either regularly, in which case the original cup shape may persist, or irregularly, which sooner or later results in the complete obliteration of the original cup. In all the transformations of the corallum, however, the polyp-cavities open on only one side;

\* Dana ('Zoophytes,' p. 724) proposed to call the submerged polyp-cavities "cells," and the projecting polyp-cavities "calicles." It seems to me that nothing is gained by having two names for the same thing under different conditions. Rejecting the term "cell," for obvious reasons, the word calicle is here used throughout for the polyp-cavity with its own immediate wall, whether it be submerged or protuberant.



where they appear to open on both sides, it is because two fronds of the corallum are fused back to back.

*Comparison with related genera Madrepora and Astræopora.*—This description enables us to compare the typical growth of a Turbinarian with that of a Madrepore. In both cases we have an axial polyp, round which the buds appear laterally. But in *Turbinaria* we have only one true axial polyp, which gives off only one ring of daughters; these themselves bud, and their buds again bud, and so on. If, as above hinted, these daughters are to be considered in their turns as axial polyps which give off parts of rings of buds, they again give off only one ring or part of a ring each. In *Madrepora* the first axial polyps give off numerous tiers of daughters, any one of which may become in its turn an axial polyp, giving off again numerous tiers of daughters, and so on.

A comparison with *Astræopora*, with which the genus *Turbinaria* is usually closely associated, will be found in the Introduction to the Catalogue of that genus, later on in this volume. We may here confine ourselves to stating that the method of budding of that genus, in which no axial polyp can be distinguished, is quite distinct from that of the Turbinarians, and the usual association of the two genera has very little real evidence in its favour.

#### GEOGRAPHICAL DISTRIBUTION.

According to the records, the Turbinarians seem to be more or less confined to the Indo-Pacific Archipelago. They occur all round the northern half of Australia, among the West Pacific Islands. In the Chinese seas, as far north as Formosa; through the Malay seas into the Indian Ocean; also in the Red Sea, and along the east coasts of Africa. I have found no record of any specimen from the coral regions of the Atlantic, or from the Eastern Pacific.\*

#### A GENERAL REVIEW OF THE VARIATIONS OF FORM AND STRUCTURE ASSUMED BY TURBINARIANS.

##### *The Variations in the Shape of the Corallum.*

Inasmuch as all Turbinarians commence life as cups, the early stages of growth may be but very briefly considered. Certain variations of form appear even in the youngest cups. They may be either concave or flat; their stalks may be either tall, thin and graceful, or short and thick. Further, the margin of the cup or plate may be thick or thin, but this depends largely upon the size of the individual calicles.

The most striking variations of form, however, occur as soon as the corallum has passed through the early cup stage. Examination and comparison of the specimens in the National Collection reveal eight different types of growth, which serve to divide the specimens, albeit somewhat arbitrarily, into as many groups.

\* References to the only recorded fossil Turbinarians will be found in the note, p. 56.

1. *Crateriform Type*.—This applies to all those Turbinarians which retain for a long time the cup form, but slightly modified. In the present state of our knowledge, it is impossible to say whether this is a natural group. Certain it is, however, that some Turbinarians grow to an enormous size as simple cups. When, therefore, we consider the improbability of the budding of the radial polyps persisting uniform round an ever-enlarging circumference, which is the only way in which the cup can retain its early symmetry, we feel bound to accept these large cups as definite specific growths, and not mere sports (Plate I.).

I propose, also, to include in this group such forms as *T. Danæ*, in which the cup shape, though modified, is always recognisable (Plates II.–V.).

This group is also useful as a temporary resting-place for the young cups which cannot be associated with any known species, it being understood that the discovery of their adult stages (adult meaning that stage which reveals the definitive type of growth) may compel us to transfer them to other groups (Plate VI.).

2. *Peltiform Type*.—This term, again, properly applies only to the early shield-like modification of the cup. The subsequent growth of this shield may vary greatly. The variations depend upon whether the early form is convex or concave. The convex specimens may form great hemispherical masses. Slightly concave forms may persist as such, the surface throwing up huge flat and branching staghorn-like processes; while the more concave forms may show most of the typical methods of growth of young cups. It is worth noting that the uncertainty of the subsequent growth of peltate young forms appears to be due to the fact that this shape is, as it were, upon the border-line between concave and convex (Plates VII.–IX.).

3. *Frondens Type*.—This group is intended to include forms in which the erect margin of the bowl-shaped cup is compelled by growth to break up into lobes, which curl round more or less vertical axes—the “cucullate infolding” of Dana (Plates X. and XI.).

4. *Foliate Type*.—This group is intended to comprise forms in which the margin of the cup continues as a complicated mass of intertwining, wavy, more or less erect fronds, which fuse irregularly with one another (Plates XI.–XV.).

5. *Mesenteriform Type*.—This includes those forms in which the margin forms open frills, which are left behind by the growing edge as cylinders. The growing edge appears lobed between the cylinders. These marginal lobes grow out horizontally, periodically bend upwards, curl round, continually forming new, more or less erect cylinders or finger-shaped processes (Plates XV. and XVI.).

6. *Tabulate Type*.—The coralla in this group form horizontal, dish-like growths. Each fresh growth covers the previous with a larger and thicker dish, there being often a space or fissure left between the two growths (Plates XVII.–XX.).

7. *Glomerate Type*.—The corallum thickens enormously in the centre, by the lengthening of the polyps, while the margin hangs down. Each new growth creeps over the one which preceded it.

The specimens in the Collection do not supply us with any *direct* proof that these



glomerate forms arise from cups. Yet the fact that their method of budding is typically that of the Turbinarians,\* and that that method of budding can be traced to the cup-formation, would justify us in assuming that, if there are no early cups in these cases, they have been secondarily lost. This stage may either have been lost by the suppression of larval dispersion, owing to the great stability of massive stocks and the secondary budding of their lengthening polyps, or have been merely obliterated by the first ring of buds branching off from their parent polyp so close to the basal epitheca that no stalk is formed, and the epitheca expands with the expanding edge of the cup.

These glomerate forms have been thought to connect *Turbinaria* with *Astræopora*, but the resemblance can clearly be only one of convergence, when the great difference between their respective methods of budding is taken into account (Plate XX.).

8. *Bifrontal Type*.—In this group the folds of the margin of the primitive cup regularly fuse back to back, so that, after the first cup stage, calicles appear on both faces of the fronds (Plates XXI.–XXIII.).

These eight types of growth do not at all exhaust the possible developments of the early cup form. A few single specimens occur which cannot be brought under any definite rule, although perhaps, when the Turbinarians are still better known, some of these may prove to be normal types of growth.

#### *Variations in the Polyp-Cavities.*

The calicles vary so greatly in size,† and in other respects, even in one and the same corallum, that one is discouraged from seeking any absolutely reliable systematic characters in them. A corallum which, for instance, forms either fronds or cylinders, may produce calicles on the fronds which bear but very little resemblance to those on the cylinders. A stock consisting only of cylinders would never be classed as specifically related with one consisting only of fronds. It is only when other stocks occur which show both forms of growth that the specific identity can be established. Here, again, it is apparent that no definitive classification of the Turbinarians can be arrived at until our collections are very much more complete. Certain distinctions nevertheless exist in the characters of the calicles, but they are often very difficult to appreciate.

*Size—diameter of the Aperture*.—In spite of a great variability in this respect, an average size can be ascertained, care being taken only to include calicles which appear to be quite normal—developing, that is, neither at the tips of prominences nor in the bottoms of valleys.

*Margin of the Aperture*.—By this I mean the fringe of the cœnenchyma immediately surrounding the calicle. The latter, in opening at the surface of the cœnenchyma, affects it in various ways. (1) The calicles project above, or are immersed in the cœnenchyma; and (2) in projecting they carry up the cœnenchyma in various ways.

\* See Ann. and Mag. Nat. Hist., (6) xv. (1895) pl. xix. fig. 7.

† This remarkable variability has been emphasised by Professor Jeffrey Bell, in a note 'On the Variations observed in large masses of *Turbinaria*,' Journ. R. Micro. Soc., 1895, p. 148; cf. also Pl. XIX.

1. While the tendency to project at all is of importance, little reliance can be placed upon the height to which the calicles protrude, every grade of protrusion being found in one and the same colony; in some situations the calicles are on long projections, in others, they are all immersed.

2. The second point is of more importance, viz. the character of the protrusion of the cœnenchyma when it does occur. As this must depend upon the activities of the polyp, it brings us—one would expect—more within reach of the inherited tendencies of the living organism, and therefore of characters of some genealogical importance. Unfortunately, the characters are not always very well marked. Among the various forms which the projecting calicles may assume, the following may be noted:—

*a.* Cylindrical, or acutely conical, with thin margin round the fossa, the aperture practically occupying the whole of the top of the cylinder.

*b.* Cylindrical, with very thick margin round the fossa, the aperture not filling the whole top of the cylinder.

*c.* Bluntly conical, which passes into

*d.* Hemispherical.

*Septa—Number.*—The number of the septa varies in a most bewildering manner, but it seems to range near some multiple of 6. Excepting when the divergence is very great, no value can be attached to it for the purposes of classification.

*Character of Septa.*—In some cases, they form a system of faint vertical ridges, running down to the columella round a widely open fossa. In the other extreme, they stand out so far as to leave but a minute pinhole-like fossa in the centre. Between these extremes, one finds every variation. I have found it useful to imagine a half-radius circle, by which to specify these variations. The septa fail to reach this circle, reach it, or project beyond it. This measurement is both artificial and rough, yet it is, at the same time, the best and the simplest I could devise.

I have not found the toothed edges of the septa, or their granulation, of much assistance in classification, although the point deserves, perhaps, more attention than I have given it. The thickness of the septa is of some importance, inasmuch as thick septa mean as a rule very narrow interseptal loculi. Further, the descent of the septa into the fossa, whether vertically or slantingly, should be noted. In the former case, the fossa is cylindrical; in the latter, funnel-shaped.

*The Fossa.*—The space bounded by the septal ridges may be wide and cylindrical; narrow and cylindrical, or funnel-shaped; deep or shallow. Great variations in the depth of the calicles may be found on one and the same corallum.

*Interseptal Loculi.*—These yield what I think may be important characters. They may be limited peripherally or not limited, i.e. open to and continuous with the furrows marking the surface of the cœnenchyma. When limited peripherally, their contour may be narrow and oblong, or nearly square, short petaloid or long petaloid. And lastly, the peripheral boundary of the interseptal loculi may be very irregular, here open and there closed. This



may occur in cases where the cœnenchyma is spongy, and the reticulum abuts against the septa, here closing the interseptal loculus, there leaving it open. The continuation of the interseptal loculi into the channels of the cœnenchyma is an index of the amount of intercommunication which exists between the polyp-cavities and the intercalicular canal system.

*The Columella.*—This varies greatly both in size and character. Taken in conjunction with characters other than the form of the fossa, on which it largely depends, it becomes of value for classification.

*The Cœnenchyma.*—This is sometimes very abundant, at other times sparse; or in other words, the calicles are at times wide apart, at others closely crowded. There is great variation in this matter. Nevertheless, when either of these characters is sufficiently pronounced and uniform in its occurrence over the whole corallum, it is of undoubted value for classification; but the variations are too great to admit of minute differences being taken into account.

The character of the surface of the cœnenchyma is subject to great alterations in one and the same corallum, being dependent largely upon the slope. On steep slopes, down which nutrient fluids would tend to stream, a pronounced ridge-and-furrow system as a rule will be found. This may be nearly straight or else gyrate, making a kind of arabesque pattern.

The ridges may be continuous, or broken up into lengths; sometimes practically disappearing, and leaving nothing but a granulation. They may be toothed in one or two or more rows, the teeth being arranged longitudinally like the teeth of a saw, or transversely; or they may stand up like stiff bristles, giving the whole surface a velvety appearance. Or again, the ridges may arch irregularly over the furrows, which then look like the burrowings under the surface of minute worms, which here and there break through.

The furrows, again, may not be parallel, but reticulate over the surface, so that the ridges break up into irregular islands within the meshes formed by the furrows. The pores leading into the canal system open in the bottom of the furrows, and show traces of variation which do not appear to be accidental.

The ridge-and-furrow system may be altogether displaced by a spongy texture either of lamellæ or of fibres. A coarse spongy character may occur at any time, in patches, as an index of very rapid growth; it is, for instance, the invariable character of the growing edges. It is only of value when it is found over the whole surface of the corallum, there being no indication of abnormally rapid growth.

There is some ground for believing that the aspect of the cœnenchyma is due to local influences. A group in the collection from Formosa have a remarkable superficial resemblance. The same is the case with the specimens from Tongatabu, and, again, from Shark's Bay. These resemblances are entirely superficial, and due in each case to some local peculiarity of the cœnenchyma. It appears as if, in each case, the special environment fixed the character of a cœnenchyma. Whether this environment is climatic or faunistic it is impossible to say. The number of larvæ of parasitic organisms found attached to corals seem to forbid us to exclude the latter suggestion.

The interrelationship between the characters of the cœnenchyma and of the calicles is a difficult subject, which, however, will some day have to be worked out. A change in the environment, leading to slight changes in the secretion and deposition of the skeletal substance, will not only affect the cœnenchyma but alter the aspect of the calicles.

#### ON THE ATTEMPT TO ARRANGE THESE VARIATIONS UNDER SO MANY SPECIFIC HEADINGS.

In dividing the Turbinarian coralla into groups, according to their methods of growth, the present writer places this feature in the foremost rank of importance. This is done purely from practical considerations. In view of the enormous amount of variations in the calicles, often on one and the same stock, and of our complete ignorance as to the laws governing these variations, it seemed at present hopeless to find any satisfactory leading character among them. Hence, in this Catalogue, they take a second place in the systematic arrangement.

The objections to grouping primarily according to the methods of growth are, however, very serious. In the first place, the methods of growth pass into one another, and it is not always easy to decide whether a specimen shows one or the other type of growth; in the second place, a long series of specimens which, from their calicles, and from their many transition forms, are clearly related, may show almost every type of growth. Still more serious, again, is the fact that in the Torres Straits we find Turbinarians widely differing in the characters of their calicles, yet revealing exactly the same methods of growth, which shows that the form of the corallum is, in these cases at least, due to the environment. The same seems also to be learnt from the fact that there are what appear to be local forms of growth, very striking, but confined entirely to limited areas. For instance, the very striking form assumed by *T. peltata*, described and figured by Ortmann\* as "*T. maxima*" from Singapore, closely resembles a specimen in the National Collection from the same locality. It looks as if this were a local form of growth. Two specimens of *T. peltata*, from Mauritius, differ in form from all other specimens of *T. peltata* in the Collection. Are these local forms of growth of any value? If we classify strictly according to growth-forms, we should have to answer in the affirmative. But this would lead to a needless splitting of specimens, closely united by other characters.

If, then, in the face of these facts, the types of growth are still chosen as the leading principle in classification, it is because there really appeared no choice. No other characters presented themselves with sufficient certainty or constancy to be made use of.

Theoretically, perhaps, the leading feature should have some connection with the forms of the calicles—perhaps should even be supplied by them—inasmuch as they have the best claim to represent the individual polyps which build the colony. This, indeed, as we have

\* Zool. Jahrb. Abt. Syst., iii. (1888) p. 160, pl. vi. fig. 4.



seen, has to be the case when the method of growth fails us as in the instances given above. The objections to this, however, are not only to be found in the variation of the calicles on one and the same specimen, but in the practical difficulty of making exact comparisons. The smallness of the calicles, and the impossibility of carrying the impressions long enough and entire enough in the mind, prevent the exact comparison which is necessary if the calicles are to be chiefly relied upon. Perhaps when photography is more largely used, and enlarged images of the calicles of every specimen can be easily obtained, and closely compared side by side, the characters of the calicles will form a safer guide than the methods of growth.

In the meantime, however, it may be borne in mind, that the form of the corallum is not altogether independent of the form of the individual calicle, the corallum itself being but an aggregate of individual calicles.

In view, then, of the unsatisfactory nature of any classification based upon these two chief variations, the oft-repeated question once more arises, Is any classification of the various forms composing a genus into separate clearly defined species possible? I shall not attempt to give any answer to the question in the abstract, but confine myself to describing the result of my own experience while working over the Collection of Corals for this and the two following Catalogues (*Astræopora* and *Montipora*).

The only specimens which can be claimed with absolute certainty as specifically identical are a few which have in each case been gathered at the same place and time, and resemble one another as closely as if they were two fragments of one and the same stock. Beyond these no certainty exists, and strict regard to the variations of form and structure would compel us to label all the remaining specimens as different species or varieties. Further, I do not remember ever having seen a specimen in other private or public collections which exactly recalled any single specimen in the British Museum. Are all these to be classed as new species? Such a course is only possible when the collection dealt with is very small; but when the number of specimens is measured by hundreds, one's courage fails. Hence recourse is had to a recognised but hardly satisfactory system of grouping: certain striking and conspicuous specimens (or single specimens which have already been described by previous workers) are selected as types, and the remainder are divided, according as, in the opinion of the individual worker, they approach one or the other of these favoured specimens.

The types are thus in the highest degree arbitrary and accidental, as is also, it must be confessed (though in a less degree), the selection of other specimens to be associated with them.

In the following Catalogue, the 260 specimens of Turbinarians are grouped round some fifty such types. These types are merely so many different forms assumed by specimens of the genus *Turbinaria* selected for description. The associated specimens appear to resemble these types more nearly than they do any of the other types; but that they are specifically identical with the type, or with one another (except in the few cases above referred to, where their relationship is indisputable), is more than I should care positively to assert. All that I can actually affirm is, that the position assigned to them appears to me to be the best.

It seems to me certain that we are rapidly nearing the time when our ever-increasing collections, revealing as they do the infinite grades of variation presented by living organisms—especially by stock or colony-forming animals, such as Corals in which the varying factors are doubled—will compel us to break loose from the restraint of the Linnean “species.”

It should be stated, in conclusion, that in cataloguing the specimens under each heading, I have been guided by morphological rather than by chorological considerations. If the collection were complete it is probable that the two would coincide, i. e. we should see the transformations in external structure following definite geographical lines. Large as the Collection is, both it and our knowledge are far too fragmentary for us to hope, for a long time to come, to be able to express the morphological variations by definite sequences of geographical names.



## LIST OF SPECIES.

(An asterisk implies that the species is not represented in the Collection.)

## I. TURBINARIÆ CRATERIFORMES.

1. *T. crater.*
- \*2. *T. cinerascens.*
3. *T. danæ.*
4. *T. laminata.*
5. *T. edwardsi.*
6. *T. plicata.*
7. *T. undata.*
8. *T. speciosa.*
9. *T. mollis.*
10. *T. aurantiaca.*
11. *T. æqualis.*
12. *T. pustulosa.*
- \*13. *T. quincuncialis.*
14. *T. nidifera.*
15. *T. abnormalis.*
16. *T. pocilliformis.*

## II. TURBINARIÆ PELTIFORMES.

17. *T. peltata.*
18. *T. patula.*
19. *T. orbicularis.*
20. *T. radicalis.*
21. *T. agaricia.*

## III. TURBINARIÆ FRONDENTES.

22. *T. frondens.*
- \*23. *T. brassica.*
24. *T. auricularis.*
25. *T. calicularis.*
26. *T. porcellanea.*

## IV. TURBINARIÆ FOLIATÆ.

27. *T. magna.*
28. *T. irregularis.*
29. *T. robusta.*
30. *T. pulcherrima.*

31. *T. crispa.*
32. *T. sinensis.*
33. *T. tubifera.*
34. *T. venusta.*
35. *T. aspera.*
- \*36. *T. gemmulata.*

## V. TURBINARIÆ MESETERIFORMES.

37. *T. mesenterina.*
38. *T. conica.*
39. *T. lichenoides.*
40. *T. reptans.*
41. *T. brueggemanni.*

## VI. TURBINARIÆ TABULATÆ.

42. *T. reniformis.*
43. *T. foliosa.*
44. *T. rugosa.*
45. *T. crassa.*
46. *T. elegans.*
47. *T. veluta.*
- \*48. *T. marmorea.*

## VII. TURBINARIÆ GLOMERATÆ.

49. *T. stellulata.*
- \*50. *T. palifera.*
- \*51. *T. parvistella.*
52. *T. globularis.*

## VIII. TURBINARIÆ BIFRONTALES.

53. *T. bifrons.*
54. *T. conspicua.*
55. *T. gracilis.*
56. *T. dendrophyllia.*

## IX. TURBINARIÆ VARIE CONTORTÆ.

57. *T. contorta.*
58. *T. subversa.*

## SYSTEMATIC ARRANGEMENT OF THE SPECIES.

### Group I.—TURBINARIÆ CRATERIFORMES.

(Containing those Turbinarians which, in the adult condition, appear to depart least from the early cup shape.)

#### Species 1. *Turbinaria crater*. (Pl. I.; Pl. XXXI. fig. 1.)

? *Madrepora infundibuliformis*, Linnæus,\* 1766, Syst. Nat., i. p. 1282.

*Madrepora crater*, Pallas, Elenchus Zooph., 1766, p. 332.

*Madrepora crater*, Esper, Fortsetz., 1797, i. p. 91, tab. lxxiv., and ii. p. 15, tab. lxxxvi.

*Turbinaria crater*, Oken, Lehrb. d. Naturg. Zool., 1815, i. p. 67.

*Explanaria infundibulum*, Lamarck, Anim. sans Vert., 1816, p. 255.

? *Gemmipora crater*, Blainville, Man. d'Actin., 1834, p. 387; and Atlas, pl. lvi. figs. 6, 6a; ? *Turbinaria crater*, M.E. and H., Les Coralliaires, iii. (1860) p. 165; *non Turbinaria crater*, Quelch, Chal. Rep., 1886, xvi. p. 166.

*Remarks on the Synonymy.*—Owing to the fact that all Turbinarians typically commence life as cups, the name *crater* has been given to young examples of many different species. Owing, moreover, to the shortness of the descriptions, it is not now possible to ascertain to what types authors' specimens really belonged. Only where figures are given, or where some unmistakable characteristic is mentioned, is this possible. The first figures given are those by Esper, which agree fairly well with Pallas' original description, and must, therefore, be taken as representing the true *T. crater*. De Blainville also gives a figure, which may or may not be the same species as that figured by Esper, inasmuch as it clearly represents a very young specimen, whose ultimate growth may depart entirely from the crateriform type. Lastly, Quelch, in his 'Challenger' report, has given the name *T. crater* to three specimens, which appear to me to differ too greatly from one another, and from Esper's figure, to be classed together under this specific name.

*Description.*—Corallum more or less regularly cup-shaped, with thin margin (2–3 mm.), wrinkled externally, and often wavy. The cup expands directly from the base, making an angle with it; the stalk of the young cup being practically obliterated.

The calicles, arranged close together, in irregular wavy concentric rows, which are

\* This is the last name given by Linnæus; in 1737, in his 'Hortus cliffortianus,' p. 480, he described certain Turbinarians as *Millepora cyathiformis turbinata interius prolifera*, while in 1760, in the 10th edition of the Syst. Nat., p. 789, he called them *Tubipora infundibuliformis*.



about the width of a calicle apart, hardly project above the surface, and look upwards. Their round or round-oval apertures vary in diameter from 1.5 to 2 mm., and the number of septa varies greatly in different specimens, as well as on one and the same specimen (16-24). The septa, seen from above, project beyond the half-radius circle, but bend round and slope gradually down from the margin of the calicle; in the bottom of the small round-oval but shallow fossa, is the indistinct, often thin and ridge-like columella. The interseptal loculi, though not sharply bounded peripherally, are nearly long petaloid.\*

Coenenchyma finely granular, where the ridge-and-furrow system is not marked.

This description, which agrees with that of Pallas (as far as his description goes), is based upon a large specimen (see Pl. I.) in the Collection from some unknown locality, which had been labelled "*T. crater*, Pallas" by so careful a worker as Brüggemann. The specimen, further, compares fairly well with Esper's drawings. It is an almost perfectly regular cup, 40 cm. across, and 14 deep; the circumference of the stalk is also approximately 40 cm. Pallas mentions having seen specimens more than a foot across. The fine specimen here described shows attempts to form buds from the outer face—a phenomenon also mentioned by Pallas.

In addition to this specimen, there are in the Collection at least eight cup-shaped Turbinarians from Australia, which have some claim to being classed specifically with the one described. No two of them are exactly alike, and each differs in some one or more points from the specimen upon which the description given above is based.

The nearest is a large cup from King's Sound, West Australia, 50 cm. across, 25 deep. Its rim is so wavy that it is no longer circular. The calicles are arranged very much as in the above description. The specimen is infested with a number of Balanids. In other specimens, also from King's Sound, the calicles are not so crowded, the septa are shorter, not reaching to the half-radius circle, more numerous, and the fossa is larger, with a well-developed columella in the base.

One remarkably regular cup, also from King's Sound, some 30 cm. across, is distinguished by its minute calicles. It appears as if the minute submerged calicles found only in the bottom of the last-mentioned specimens had spread over its whole surface. Their general arrangement is the same, but being smaller, they appear less crowded. There are other specimens, again, in which both small and large calicles are found.

A few of the smaller of the specimens from King's Sound have their edges crumpled by overcrowding, or else by parasitic growths. They closely resemble, and perhaps should be united with *T. undata*.

In addition to the above, again, are two from Thursday Island, Great Barrier Reef. The large one, 25 cm. in diameter, growing on a mother-of-pearl shell, has the calicles looking upwards and outwards; and the septa, not projecting beyond the half-radius circle, bound a larger and deeper central fossa. The smaller specimen is an almost perfect cup, 14 cm. in diameter, and growing from the bent-up margin of a former cup, which had been overturned and killed. This differs from its companion in the more sparse arrangement of the calicles, which are also more oval, and in the greater size and depth of the elliptical fossa, and consequent distinctness of the columella.

In most of the specimens, especially in the larger, the calicles in the bottom of the cup

\* See the list of taxonomic characters given in the Introduction, p. 17.

are completely obliterated and those immediately round this vacant area are immersed by the cœnenchyma. The large specimen on which the description is based shows very clearly the increasingly more pronounced character of the striation of the inner surface from the margin of the cup inwards. The furrows which give rise to the striated appearance are canals not yet bridged over with skeletal matter. Where the downward pressure of the fluid in the inside is greatest, i. e. just round the bottom of the cup, this canal system is therefore most pronounced. The canals here seen from above often look like a mill-race rushing down between the calicles.

<i>a.</i> Locality not recorded.	[Register No. 71. 11. 22. 1.]
<i>b-f.</i> King's Sound, West Australia.	Saville-Kent Coll.
<i>g-i.</i> Three younger specimens with frilled edges, also from King's Sound, West Australia.	Saville-Kent Coll.
<i>j, k.</i> Thursday Island, Great Barrier Reef.	Saville-Kent Coll.
<i>l.</i> Two small cups together, from Roebuck Bay, West Australia.	Saville-Kent Coll.

Species 2. *Turbinaria cinerascens*.

*Madrepora cinerascens*, Ellis and Solander, Nat. Hist. Zooph., 1786, p. 157, tab. xliii.

*Turbinaria cinerascens*, Oken, Lehrbuch der Naturgeschichte, Zool., i. (1815) p. 67.

? *Gemmipora cinerascens*, Dana, Zoophytes, 1848, p. 411, pl. xxx. fig. 11.

*Non Turbinaria cinerascens*, Quelch, Chal. Rep., 1886, p. 167.

(*Remarks on the Synonymy*.—This having been, like *T. crater*, one of the earliest recorded species of Turbinarian, has been made the receptacle for so many stray specimens that it is now impossible, without close examination of the actual specimens involved, to unravel the synonymy.)

*Description*.—Corallum cup-shaped, with stout, almost obliterated stalk, thin, wavy edges, wrinkled externally; the whole thickness of the rim occupied by a chain of young buds.

Calicles hardly protuberant, but with raised, circular, ring-like margins, very conspicuous, not crowded, varying greatly in size. Septa about 16, not projecting far into the cavity, but sloping down into the rather deep and conspicuous fossa. Columella not very distinct. Interseptal loculi bounded peripherally, long or short petaloid.

Cœnenchyma delicately striated, giving a soft appearance to the surface, though very rough to the touch.

This diagnosis is entirely founded upon the description, and upon the very beautiful figure given by Ellis and Solander. This drawing so accurately represents well-known Turbinarian characters that we cannot avoid the conclusion that it is a faithful copy of an actual specimen.

There is, unfortunately, no single specimen in the National Collection which resembles it. This fact alone makes me greatly doubt much of the synonymy, as it is evident that the type is not a common one. Its cup shape, for instance, makes it practically certain that it is not



Ehrenberg's *Explanaria cinerascens*, the genus *Explanaria* of Ehrenberg being reserved for specimens without stalks.\* That it is not Ehrenberg's *microstoma* from the Red Sea, as suggested by Dana, I should infer from the fact that its habitat is given as the Indian Ocean.

Rehberg † describes it as "one of the commonest species," occurring also at Zanzibar, and often reaching "a size of 2 metres." I venture to suggest that it is only common because the name has been too frequently applied.

The figure in Ellis and Solander is somewhat puzzling. The method of growth of the specimen is not clear. It can perhaps best be explained as a group of at least four cups of about the same age, three at one elevation; the fourth, behind the other three, must stand on some portion of the substratum at a higher level. There are several specimens in the National Collection with two young cups of about the same age and of the same species growing side by side, although they do not in such cases coalesce, as they are represented to have done in the figure referred to.

Species 3. *Turbinaria danæ*. (Pl. II.; Pl. XXXI. fig. 2.)

*Description.*—The original cup becomes variously modified, but is always recognisable. It is generally flat and open, but may also be deep and vasiform. The cup may attain a diameter of more than a foot with but slight undulations of the surface. On the other hand, the folding or frilling is often very pronounced, but irregular. The folds are open, but after growing taller and taller suddenly cease; the margin tends to close round the fold and to smooth out again, as if once more to try and form a horizontal cup rim. The folds are left as thick conical projections, hollow underneath, within the cup. The margin is thin, and the stalk short and stout.

The corallites project from 1 mm. on even flat surfaces, to 5 mm. above the cœnenchyma on the ridges of the folds. The apertures are nearly round (1.5 mm.) in the former case, more oblong when situated at the top of the tall conical projections. The valleys are thickly studded with minute secondary buds immersed in the cœnenchyma.

The septa vary from 18 to 24. Their upper edges project as far as the half-radius circle, and then descend sharply or with a curve to bound an elliptical fossa; at the bottom of which is a clearly defined columella surrounded by a ring of interseptal loculi running down all round it. The interseptal loculi round the margin are sharply circumscribed, i.e. they are not continued into the surface furrows of the cœnenchyma, but the material separating the two may be extremely thin, the upper ridges of the septa being simply bound together peripherally by very thin skeletal plates.

The cœnenchyma is internally granular near the margin, but shows the furrows more distinctly nearer the bottom of the cup. Externally it looks very solid and strong, the furrows being like the more or less parallel burrowings of a minute larva in a solid substance.

\* Corallenthiere des rothen Meeres, 1834, p. 82. See further *T. mesenterina*, synonymy, p. 57.

† Abh. Naturwiss. Verein Hamburg, xii. (1892) p. 44.

This form differs from *T. crater* in the conically protuberant calicles with very thin margins round the apertures, and also in its tendency to form pronounced folds which may stand up as high ridges radiating from near the centre of the cup, these ridges mounting up into conical processes thickly covered with tall projecting calicles. The type specimen shown in the plate is a good example of this method of frilling. This species is certainly not far removed from *T. foliosa* (cf. Pl. XVIII.), from which it differs chiefly in the greater coarseness of the calicles.

On the other hand, the specimens that fold but little, and have only non-protuberant, or but slightly protuberant calicles, might almost be classed with *T. crater*.

Again, the tall conical calicles recall the *T. brassica* of Dana,\* but its whole method of growth seems different, and further the calicles in *T. brassica* are distributed evenly and sparsely over the whole corallum, whereas in this coral the tall conical calicles are confined to the tall ridges, as in *T. foliosa*, elsewhere they are but slightly protuberant.

Conical calicles occur also in a small cup described as a new type, *T. abnormalis* (p. 36), but the contrast is great. *T. abnormalis* has the tall calicles springing from the bottom of its cup, hence its name, whereas the coral under discussion has the corallites in the bottom of the cup, and in the troughs between the ridges, immersed and so crowded as to imply very rapid secondary budding.

The method of growth in which the margin grows round the folds is not unlike that which characterises the mesenteriform type, but in this case it is quite irregular, the processes formed by the folds ranging from tall, thick cones to mere undulations of the surface.

There are in all six complete specimens, all of them large cups, the smallest being 22 cm. in diameter.

There is considerable variation among the calicles in the different specimens, as there is indeed among the calicles on one and the same specimen. Yet they appear linked together in a way which makes it difficult to separate them.

<i>a.</i> Locality not recorded.	[Register No. 93. 7. 1. 6.] (Type.) (Pl. II.)
<i>b.</i> Malay Seas.	India Museum.
<i>c.</i> West Singapore (in three pieces).	Raffles Museum.
<i>d.</i> Locality not recorded.	[Register No. 80. 12. 6. 3.]
<i>e.</i> Australia.	Lord Derby [P.]
<i>f.</i> Locality not recorded.	[Register No. 55. 1. 10. 2.]
<i>g.</i> Locality not recorded.	[Register No. 93. 7. 1. 10.]
<i>h.</i> A small fragment.	[Register No. 43. 3. 6. 114.]
<i>i.</i> Formosa.	Swinhoe Coll.

There is, in addition, a young cup somewhat resembling this coral, especially in showing the same method of commencing to fold and again flattening out. The calicles also are not unlike, but, perhaps owing to the youth of the specimen, they hardly protrude at all. It is from the Malay Seas, and apparently collected at the same time as specimen *b*. It may therefore be an early cup stage of this coral. It, however, shows affinity with the next type.

<i>j.</i> Malay Seas.	India Museum.
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\* Zoophytes, Atlas, pl. xxix, fig. 1.



Species 4. *Turbinaria laminata*. (Pl. IV.; Pl. XXXI. fig. 3.)

*Description*.—Corallum an open cup, edges tending to curl outwards and downwards, margin thin and externally wrinkled. Stalk thin.

Calicles evenly distributed, crowded, somewhat more than their diameter (2 mm.) apart; immersed in level *cœnenchyma* or else with the thin regular elliptical margin slightly raised, in which case the surface sinks into slight valleys between rows of calicles or between individual calicles, which latter then appear to protrude. Septa 18 to 24, thin and delicate, descend with a very slight downward curve (concave upwards) to the columella, which is thus nearly on a level with the margin of the calicle. The columella is an open reticulum of the thin septal plates, is irregular in shape, and fills up about the half-radius circle. The inter-septal loculi are conspicuous, owing to the delicacy of the septa; sharply bounded peripherally, short, to long, petaloid.

The *cœnenchyma* is built up of flat, porous laminae parallel with the surface, this character appearing even in the reticulum of the growing edge. Over certain areas, especially in regions where the calicles are all immersed, and to a less extent in the valleys between the calicles, the pores are so numerous that the corallum has a blackish look. Elsewhere, in regions where the corallites tend to rise above the surface as round protuberant calicles, the laminae are less porous, and smooth and white, making the corallum look stony. The laminate character of the *cœnenchyma* is very marked externally.

There is only one *Turbinarian* in the Collection with the *cœnenchyma* developed as in this type specimen. There are, however, two other specimens which seem to tend that way, as indeed, does the young cup which I have already associated with the last type, as probably its early stage. The two specimens referred to are united here with this type chiefly on account of the stony character of the *cœnenchyma*, which is here and there laminate, but largely also a ridge-and-furrow system. Again, their calicles differ in having a definite oval fossa surrounded by a ring of vertical septa, the absence of such a fossa being a marked feature in the type. On comparing all the specimens of this and the last type, there can be little doubt that they are all related forms, while no two specimens could be less alike than are the type specimens themselves.

*a.* Locality not recorded.

[Register No. 46. 7. 1. 9.] (Type.)

? *b.* Locality not recorded.

[Register No. 41. 1. 13. 38.]

This latter is a thin, open cup, with somewhat more protuberant calicles, which are smaller, with sharp, protuberant elliptical margins. It appears to belong somewhere between this type and the young specimen attributed to the last.

? *c.* Locality not recorded.

[Register No. 93. 7. 1. 5.]

This is a distorted cup, very deep, and flattened so that the two opposite edges nearly meet. The calicles here are larger and slightly more protuberant.

Species 5. *Turbinaria edwardsi*. (Pl. III.; Pl. XXXI. fig. 4.)

*Description*.—Corallum nearly regularly crateriform. The slight indications of folding perhaps due to parasitic growths. The cup expands directly from the base. The margin thick (3.5 to 4 mm.), with a row of conspicuous young calicles.

The calicles protuberant, short, truncated cones looking upwards, closely arranged side by side in irregular rows which are also close together. Aperture round-oval, 2 mm., very uniform; margin also uniform, .75 mm. thick, its outer edge is formed by the irregular cœnenchyma which changes suddenly into the system of thin, narrow and rather crowded septa (24); these fall far short of the half-radius circle. The rather deep fossa is thus very conspicuous, with perpendicular walls, and with a large, not very protuberant columella, which is light and spongy.

The cœnenchyma shows a delicate pattern of fine ridges and furrows. The ridges tend to be solid and continuous in the base of the cup and round the bases of the protuberant calicles, but finely toothed or divided on the calicles themselves, which thus have a velvety appearance. In the furrows, under a pocket-glass, the pores are conspicuous.

The type specimen is an open cup, 26 cm. by 24, and standing 12 cm. high. The walls are wavy and the margin thick, except at one point where it dips and is only the thickness of the budding calicles. The bottom of the cup is filled with cœnenchyma in which are a few scattered calicles, completely immersed, funnel-shaped, and some like minute pin-holes, with eighteen unequal septa and a columella consisting of a single keel-like plate. The immersed calicles pass gradually on the slopes of the cup into the protuberant calicles. The specimen is from King's Sound, West Australia.

Another specimen, distorted by parasites in such a way that at two opposite points the growth of the cup was arrested, appears to belong here. The two sides which have grown, form two wings, some 12 to 13 cm. deep. While the general character of the calicles agrees with the description, there is a great deal more variation in size and degree of protuberance. The cœnenchyma is also somewhat coarser, although of the same type. Further, the same immersed pin-hole calicles are at the bottom of the cup. The specimen is especially interesting on account of its having been attacked by some parasite, which in its action, may be likened to a gall. Almost every stage in the growth of these "galls" can be followed. They commence as proliferations of the cœnenchyma generally on the margin of a calicle. Instead of the normal arrangement, the reticulum is looser, and shows all the signs of exuberant growth. Here and there this growth appears as if pouring down into the calicles, filling up the fossa, and ultimately forming a hemispherical excrescence, which may smother several calicles. Or again, an excrescence appears to be lying upon the ordinary cœnenchyma as if it were a foreign body, but, by tracing it back to its origin, it is seen to be a proliferation of cœnenchyma overflowing, from a centre of growth, the surrounding parts.

Many of the larger excrescences have a hole in the top as if an animal had escaped. The hole leads into a cavity considerably larger than an ordinary polyp cavity, and with all the appearance of having been excavated.

The other specimens which I associate with this type are small cups from 1.4 to 9 cm. in diameter, some deep, others flat and peltate. These differ from the type chiefly in the character



of the coenenchyma, which also affects the margins of the calicles. The smaller the cup, the more pronounced is the stalk. But this, in later stages, is obliterated by the thickening of the wall of the cup, till it appears to expand directly from the base.

<i>a.</i> King's Sound, West Australia.	Saville-Kent Coll. (Type.)
<i>b-g.</i> King's Sound, West Australia.	Saville-Kent Coll.
<i>h, i.</i> Roebuck Bay, West Australia.	Saville-Kent Coll.

There is another specimen, 95. 8. 29. 12, which I think should come under this head. It is a single fan-shaped frond (11 cm. deep), somewhat crumpled, growing at the edge of a decayed fragment which, on examination, proves to have been part of a large stock of the same coral. The frond thus never started normally from a cup, but as a revival of a portion of a large dying stock. The calicles agree in general characters with those of the preceding, while the coenenchyma has the same saw-like ridges with deep furrows, but much finer and more delicately cut than in the type. This gives the specimen a peculiar appearance which led me at first to consider it a new species.

<i>j.</i> Roebuck Bay, West Australia.	Saville-Kent Coll.
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Species 6. *Turbinaria plicata*. (Pl. IV.; Pl. XXXI. fig. 5.)

*Description*.—Corallum cup-shaped, stalk short and not very thick, cup shallow, with walls sloping gradually outwards, but here and there bent sharply upwards and irregularly crumpled up. This crumpled edge bends inwards towards the axis of the cup. The margin of the cup, where it grows freely outwards, thins very rapidly (to 2 mm. and less) being simply a row of young calicles flattened in the plane of growth.

Calicles immersed, only near the edges do they show any signs of rising above the coenenchyma, fairly evenly distributed, from 3 to 5 mm. apart. The neat elliptical aperture averages 1.5 mm. in long diameter. The (ca.) 24 septa reach to about the half-radius circle, bending round from the edge to descend perpendicularly round a conspicuous elliptical fossa. The corallite seems to have no proper wall, as the interseptal loculi run in as irregular gashes which can be followed far into the reticulum of the coenenchyma. The septa are direct continuations of the ridges of the coenenchyma, and like them, are rough and granular. Two ridges sometimes meet together in a septum. The oval columella is conspicuous, protuberant, and has a thick, granular directive keel.

The coenenchyma is smoothly and finely engraved by a ridge-and-furrow system, twisting irregularly about among the submerged calicles. The ridges have rows of irregular granules along their edges. On the under surface, the ridges and furrows run more evenly in the line of growth, the former being more solid and stony, with, however, faint traces of the granules along their uppermost edges.

There is, unfortunately, only one specimen. It is the greater part of a cup 15 cm. in diameter and 7 high. One half has been broken away, but the larger half with the stalk

fortunately persists. The species is not based solely upon the crumpled character of the edges, which, however, appears to be normal, although it may be due to contact with other growths or to the irritation of parasites, but also upon the character of the calicles, which appear to be distinct from those of any other Turbinarian. The only other specimens with such a conspicuous columella, differ entirely in other respects from this one.

*a*\* Roebuck Bay, West Australia.

Saville-Kent Coll. 95. 8. 29. 11.

Species 7. *Turbinaria undata*. (Pl. IV.; Pl. XXXI. fig. 7.)

*Description*.—Corallum an open shallow cup with very short but very thick stalk. The edge is thrown up into sharp waves, not, however, in vertical planes but sloping at an angle with the plane of the rim of the cup.

The calicles elliptical, protuberant on the ridges and slopes of the folds, with thick, almost perpendicular, walls thinning off round the edge of the aperture (2 mm.). Septa thick, granular (ca. 20), not reaching the half-radius circle at the margin of protuberant calicles, but sloping down around the long-oval, funnel-shaped and deep fossa. The columella is a very protuberant row of distinct granules, either single or double. In very large double calicles it may be a conspicuous square, triangular, or oblong mass of fine granules.

The interseptal loculi are not sharply bounded peripherally, but run on irregularly into the furrows of the cœnenchyma.

The cœnenchyma is very delicately and deeply cut. The ridges are not sharply circumscribed, but tend to be flaky and reticular, often very fine and granular.

There is one complete adult specimen of this coral, 18 cm. in diameter; the stalk is not more than 2 cm. high, but reaches 7 cm. in diameter. In the character of the folding and in general aspect, it resembles specimens both of *T. crater* and of *T. dana*, with either of which perhaps it might be united. The calicles, however, differ.

The specimen is of interest on account of the peculiar character of some of the young submerged calicles. These appear to connect it with a young cup previously labelled *T. crater* Pallas, but which, on account of this peculiarity I had ventured, in spite of its immaturity, to class as a new species.

The cup referred to is circular (3 cm. across), open, evenly concave; edges with a slight tendency to wave, calicles circular or elliptical, without fossæ, septa and columella being flush with the margin. The stalk is short, without expanded base, having grown round some projection or small fragment.

The calicles are peculiar in showing no tendency to rise above the cœnenchyma in bending upwards. Their upper edges, on reaching the surface of the cœnenchyma, cease to grow. The abaxial margins, however, continue to grow outwards, so that the calicles round

\* A Balanus on this specimen deserves attention; the arrangement of the teeth on its shell is strikingly like an imitation of the surface markings of the cœnenchyma. The suggestion of imitation is strengthened by the presence on the shell, of two arrangements of "teeth" which I at first mistook for irregular calicles. It was only by close examination that I became satisfied that the shell was not covered by cœnenchyma.



the edge of the cup have a very abnormal appearance. The keel-like columella is close to the proximal wall, which has but few traces of septa, while laterally and distally to the columella the septa are very pronounced, forming a fan-like arrangement flush with the cœnenchyma. Towards the bottom of the cup, the symmetry is gradually regained, the calicles bending up further and developing evenly in the thickening cœnenchyma. The elliptical calicles are 2 mm. long. The septa (about 20) cross the half-radius circle, the small fossa is almost filled with the protuberant columella. The calicles are about 3 mm. apart in the line of growth, but side by side may be about their own width apart.

The presence of these asymmetrical calicles on the larger specimen, together with the resemblance of the cœnenchyma in the two cases, makes it probable that the smaller is the young form of the larger. That young forms with completely immersed calicles may grow into forms with protuberant calicles appears probable also from a comparison of specimens *b* and *i* on p. 27.

*a.* King's Sound, West Australia.

Saville-Kent Coll. (Type.)

? *b.* (A minute cup) locality not recorded.

Species 8. *Turbinaria speciosa*. (Pl. V.; Pl. XXXI. fig. 6.)

*Description*.—Corallum circular, the cup being flat or open funnel-shaped, with short, thick stalk. The surface is thrown into folds radiating almost from the centre. Former folds grown round and left behind by the growing edge become cylinders or thick finger-shaped protuberances.

Calicles slightly protuberant, closely crowded, obliterated in the centre, look upwards. Aperture circular (diameter from 2 mm. maximum) and not occupying the whole of the top of the prominence, but leaving a thin margin of cœnenchyma from which the clearly marked thin septa (14 to 18) project, reaching (seen from above) to the half-radius circle, but sloping down from the margin so that the fossa is funnel-shaped and deep. Columella small and indistinct. The interseptal loculi short petaloid.

On the upper surface, the cœnenchyma is granular, but on the under surface, it is delicately and regularly striate, the striæ being wavy furrows running down towards the stalk.

This type is not far removed either from *T. danæ* or from *T. crater*, but differs from both in the character of the calicles and in the greater thickness of the growing margin.

The two specimens show somewhat irregularly the method of forming the cylindrical protuberances which occur so frequently in this genus. It approaches the mesenteriform type of growth.

*a.* [On mother-of-pearl shell with *T. peltata*.]  
Port Denison.

Saville-Kent Coll. (Type.)

*b.* [On mother-of-pearl shell with *T. peltata*.]

[Register No. 80. 5. 27. 1.]

Species 9. *Turbinaria mollis*. (Pl. V.; Pl. XXXI. fig. 8.)

*Description*.—Corallum a delicate cup, so thin that the polyp-cavities within its substance wrinkle its exterior much further down than usual. The delicate rim tends to bend inwards

towards the axis of the cup. Cup irregularly contorted. The graceful stalk characteristic of young specimens thickens in such a manner that the cup stands like an inverted cone.

Calicles not crowded, projecting as short, blunt cones, 2 mm. high. The aperture occupies the whole top of the cone, oval (2 mm. maximum long diameter). Septa (14 to 18) granular, irregular, continuing the ridges of the cœnenchyma, projecting (seen from above) beyond the half-radius circle, bending round gradually from the margin to descend vertically, limiting a clear, small elliptical fossa; a well-marked columella rises as a directive plate, which is thickened in the centre with granules. The interseptal loculi are long gashes in the margin, very irregularly bounded peripherally by the cœnenchyma, often continued into the furrows.

The surface of the cœnenchyma on the inside is marked by a very pronounced ridge-and-furrow system, the latter being still further deepened by the long slit-like pores opening in their depths. On the outside, the ridge-and-furrow system is well marked, especially towards the base.

This coral is named after the curiously woolly appearance of the surface of the cœnenchyma within the cup, due to the dark pores seen within the furrows. There are three specimens, one an extremely delicate and perfect cup 6 cm. across and 5 cm. high (Pl. V.). A second is about the same size, but snapped from its stem, and with the cup flattened into a fan shape. The largest specimen is a cup 15 cm. across, showing a peculiar contortion which may be typical, inasmuch as this method of folding will explain the origin of the remarkable *T. contorta* (cf. p. 74) from an original cup.

*a.* Singapore.

H. N. Ridley, Esq. (Type.)

*b, c.* [Young cups, one showing section of stalk.] Singapore. H. N. Ridley, Esq.

Species 10. *Turbinaria aurantiaca*. (Pl. IV.; Pl. XXXI. fig. 9.)

*Description*.—Corallum a cup, showing slight foldings; margin not very thin, but wrinkled externally.

Calicles not crowded, and not typically projecting. Aperture circular (diameter 1.5 mm. and less), the ring-like margin rising very slightly above the cœnenchyma. Septa (18–20) project but very little from the margin, and descend vertically, bounding a large and deep fossa. Columella compact, spongy, slightly convex. Interseptal loculi not sharply defined peripherally.

Cœnenchyma finely granular inside, outside either granular or very delicately striate.

This species has been established to contain five specimens which appear to be allied, in spite of considerable differences. The largest specimen is remarkable for a method of growth and multiplication of the individual polyps, which, if not pathological, ought to constitute it a separate species. There is sufficient evidence, however, to show that the specimen has grown under abnormal conditions, owing to what appear to have been depositions of sediment within and on the margin of the cup. The “abnormal” growths referred to deserve detailed description, as they occur in all stages. The distal margin of a calicle rises like a hood,



to a height of 3, 4, or 5 mm., and a daughter calicle appears on each side of the directive line. As the process grows, two more appear crosswise to the former two, the head of the process swelling out to form a knob with the parent polyp at its inner base. Globular heads (8 mm. high) and attached by stalks are found with over 12 calicles opening around them; many of these strongly resemble the suctorial "heads" of tape-worms. These developments occur almost exclusively either close under the margin of the cup, where its normal growth has been hindered, or in the disturbed region round the mass of sediment in the base of the cup. All the other specimens, except the smaller cup forms, show signs of unusual growth. The species is named after the yellow-brown colour of the corallum.

One of the many very minute cups in the Collection may, from the character of the calicles, belong here.

- |  |                           |
|--|---------------------------|
| <i>a.</i> (With <i>T. patula</i> ) Port Denison. | Saville-Kent Coll. (Type) |
| <i>b, c.</i> Great Barrier Reef.                 | Saville-Kent Coll.        |
| <i>d.</i> (A minute cup) Torres Straits.         | J. B. Jukes, Esq.         |

Two fragments (92. 12. 1. 660 & 675), encrusting dead masses with slightly larger and more projecting calicles, may perhaps have been broken off older growths of this species in which the original cup had been obliterated. I have accordingly labelled them "? fragments of old stocks." One of them (*e*), however, may from its growth belong to the Tabulate group.

- |                                  |                    |
|----------------------------------|--------------------|
| <i>e, f.</i> Great Barrier Reef. | Saville-Kent Coll. |
|----------------------------------|--------------------|

Species 11. *Turbinaria æqualis*. (Pl. XXXI. fig. 10.)

*Turbinaria æqualis*, Quelch, Chal. Rep. Cor., 1886, p. 168, pl. vii. figs. 3 and 3*a*.

*Description*.—Corallum persisting at least for a time as a cup, subsequent development unknown. Margin thin, with slight external wrinkling.

Calicles not crowded, either immersed or on very slight swellings of the cœnenchyma. Aperture circular, minute (1 mm. diameter and under), inconspicuous. Septa (14 to 20) radiate irregularly from the margin and of unequal length, project almost level with the cœnenchyma beyond the half-radius circle, thick\* and granular, bounding an irregular fossa. Columella indistinct, composed of irregular granules, rising at times to the level of the margin; fossa thus not apparent to the naked eye. The interseptal loculi long narrow slits.

Cœnenchyma in section massive, like solid stone; pore-canals few and only visible under a pocket-lens. Surfaces, inside and out, finely granular.

Mr. Quelch's type specimen is a small fragment of an irregularly folded margin of an old stock, the folds fused back and back. Small as it is, the fragment is covered with

\* Mr. Quelch says that the septa are thin, which is correct absolutely, but, relatively to the size of the calicle, they are thick, leaving but narrow slit-like interseptal loculi.

attached or burrowing organisms. The character of the calicles, however, in spite of the abnormal conditions of growth, justifies the establishing of a new species. Two corals have since been acquired for the National Collection, which show this character as normal in their cases.

The one from the Barrier Reef is a massive stony cup, like a mortar, with all the thinner edges broken or worn away; the character of the calicles can, however, be made out, the cœnenchyma being so massive that it has suffered little.

The other, from the Holothuria Reef, is a curved fragment showing the thin growing margin. The cœnenchyma, porous and brittle along the growing edge, becomes gradually denser till, about an inch from the edge, it is like stone. This would explain the loss of the margin all round the worn cup from the Barrier Reef.

This great density of the cœnenchyma, which is in keeping with the minute size and scattered distribution of the calicles, is the most striking characteristic of this type.

- |  |                              |
|--|------------------------------|
| a. Wednesday Island, Torres Straits, 8 fathoms.    | H.M.S. 'Challenger.' (Type.) |
| b. Great Barrier Reef.                             | Saville-Kent Coll.           |
| c. Basset-Smith Shoal, Holothuria Reef, 9 fathoms. | Lords of the Admiralty.      |

Species 12. *Turbinaria pustulosa*. (Pl. III.; Pl. XXXI. fig. 11.)

*Description*.—Corallum crateriform; margin not thin, much wrinkled; short, thick peduncle.

Calicles slightly projecting, a large proportion of the projections swelling almost into globules the size of a pea, 4 mm. in diameter. The aperture, mostly circular, averages 2 mm. in diameter, and looks upwards and inwards. Septa about 20, not reaching the half-radius circle, but bending round almost immediately to descend vertically, or nearly so, to surround the deep fossa. The columella oval, protuberant, irregularly reticulate; interseptal loculi short, wedge-shaped, irregularly bounded peripherally.

Cœnenchyma appears granular, but the ridge and furrow system is well developed, the ridges, however, being short and not continuous.

There are two specimens which are strikingly dissimilar at first sight. One is a large deep cup of a rich red-brown colour, and the other a shallower cup of a grey colour with walls much distorted apparently by pressure from surrounding objects. They appear, however, to be united by the peculiar character of the projecting calicles (which has suggested the specific name), and by the surface markings of the cœnenchyma. The distortion of the wall seen in the grey specimen is found also slightly indicated in the larger one. It consists of a turning over inwards of the margin and then a bending out again.

The calicles not showing this swollen form, either hardly project above the cœnenchyma, or are else barrel-shaped, showing all intervening stages between these two. The barrel-shaped projection leads gradually to the swollen globular calicle.

- |                                      |                            |
|--------------------------------------|----------------------------|
| a. Port Denison, Great Barrier Reef. | Saville-Kent Coll. (Type.) |
| b. Gulf of Carpentaria.              | Saville-Kent Coll.         |



Species 13. *Turbinaria quincuncialis*.

*Turbinaria quincuncialis*, Ortmann, Zool. JB. Syst. Abth., iv. (1889) p. 497.

*Description*.—Corallum regularly crateriform, deep, funnel-shaped, margin irregular, 5 mm. thick.

Calicles crowded, small (1 to 2 mm.), round, little prominent (1 mm.), frequently oblique. Septa about 16. Columella small, a mere point but distinct.

Habitat, Ceylon.

I have been unable to identify this with any of the specimens here catalogued. There are in fact no Crateriform Turbinarians from Ceylon in the National Collection.

*The following species are small cups, provisionally classed under the head crateriformes, their subsequent growth being unknown.*

Species 14. *Turbinaria nidifera*. (Pl. VI.; Pl. XXXI. fig. 12.)

*Description*.—Expanded cup 8 cm. in diameter, on a tall stout stalk. Margin thick, folded, folds fusing back to back, but with a very marked suture; young calicles round margin, large, deep, and conspicuous.

Calicles irregularly scattered, protuberant, with thick expanding margins almost like thick-rimmed cups on stalks, the base of the calicle being narrower than the aperture; secondary polyps may develop on the thick rim. Aperture oval, 2.25 mm.; septa (24 and more) project very slightly from margin and descend perpendicularly round the large deep oval fossa. Columella very marked, protuberant, compact, appearing almost too large for the polyp-cavity. Interseptal loculi not bounded peripherally.

Cœnenchyma above, rough and very porous; below, well-developed ridge-and-furrow system.

This is quite a unique specimen; the form of the calicle and the size of the columella distinguish it from all known Turbinarians. The name is suggested by the nest-like calicles, each with a conspicuous egg-shaped columella.

a. Great Barrier Reef.

Saville-Kent Coll. (Type.)

Species 15. *Turbinaria abnormalis*. (Pl. VI.; Pl. XXXI. fig. 13.)

*Description*.—Small conical cup, expands gradually from the stalk. Margin thin, and slightly undulating and wrinkled.

Calicles, in irregular concentric series, project as tall cones (5 mm. high) from the base of the cup, but diminish in height towards the edge. Aperture nearly circular (diameter 2 mm. and less), occupying nearly the whole top of projection, a very thin margin of cœnenchyma

binding together the septa peripherally. Septa 20 to 22, not reaching the half-radius circle, descend vertically to bound a large, deep, round or oval fossa with well-marked columella. Interseptal loculi not sharply defined peripherally, but distinct, oblong.

Cœnenchyma granular both inside and out.

This specimen, measuring 8 cm. across and 7 cm. high, at first appeared as if it might be a young cup stage of Dana's *T. brassica*, but as it is impossible to establish any such connection without the intermediate growths, and the calicles do not agree, I felt bound to place it separately. Its most singular characteristic is that the calicles in the base of the cup, instead of being obliterated, as in the majority of Turbinarians, rise up as tall cones. This unusual method of growth suggested the specific name.

a. Great Barrier Reef.

Saville-Kent Coll. (Type.)

Species 16. *Turbinaria pocilliformis*. (Pl. VI.; Pl. XXXI. fig. 14.)

*Description*.—Corallum symmetrically bowl-shaped, margin thin, almost regularly circular, wrinkled outside.

Calicles in irregular concentric series round the margin, their thin margins slightly projecting, obliterated in the base. The aperture circular (diameter 2.5 mm. and less). The septa (24) descend from the margin vertically without projecting appreciably across the aperture, which is thus conterminous with the aperture of the fossa; this is large and deep, with a distinct protuberant columella. The interseptal loculi show round the margin of the aperture as slight irregular notches.

The cœnenchyma is regularly granular on the outside, more coarsely so than on the inner side, the granules tending to become arranged in series which approach the typical ridge-and-furrow system.

This specimen, which measures only 9 cm. across by 7 high, is, like the last, perhaps, the early stage of some other growth-form. Until, however, we know its subsequent method of growth, its regular cup shape warrants us in assigning it a distinct place among the crateriform Turbinarians. In form, it somewhat resembles Blainville's picture of *Gemmipora* (*Turbinaria*) *crater*, but the calicles prove it to be distinct.

a. North-West Australia.

Capt. J. R. Beckett. (Type.)

*Turbinaria sincensis*, Verrill,\* is described by that author as crateriform. From his description of its great size (14 inches wide and 10 high), it ought apparently to find a place here. I have, however, felt obliged to place it in the foliate group for reasons there given, cf. p. 54.



## Group II.—TURBINARIÆ PELTIFORMES.

*Turbinariæ in which the early cup form tends to be disc-shaped.*

Species 17. *Turbinaria peltata*. (Pls. VI., VII., VIII.; Pl. XXXI. fig. 15.)

*Madrepora peltata*, Esper, Fortsetzungen, Th. i. 1797, p. 27, Taf. xlii.

*Gemmipora peltata*, Blainville, Manuel d'Actinol., 1834, p. 387; non *Turbinaria peltata*, Ehrenberg, Beit. Kennt. Korallenthiere, 1834, p. 81.

*Gemmipora peltata*, Dana,\* Zoophytes, 1848, p. 410, pl. xxx. fig. 4.

*Turbinaria peltata*, Milne-Edwards and Haime, Les Coralliaires, iii. (1860) p. 165.

*Turbinaria dichotoma*, Verrill, Proc. Essex Institute, vi. (1871) p. 89.

*Turbinaria marima*, Ortmann, Zool. JB. Syst. Abth., iii. (1888) p. 160, pl. vi. fig. 4.

*Description*.—Young corallum thick, stalked, shield-shaped, concave or convex. In the former case, it may in subsequent growth show all the typical foldings of more pronounced cup forms, or the cup may fill up with cœnenchyma between the folds and become a convex mass. The development of the early convex shield is to spread outwards and downwards as an encrusting mass.

Calicles either immersed in the rapidly growing cœnenchyma, or projecting especially on protuberances and folds. In the latter case the aperture fills the top of the projection. Aperture circular (varying greatly in diameter from 10 mm. (Milne-Edwards) to 4 mm.). The septa are normally 24, but in large calicles may be 32 or more. The 24 septa can at times be seen to differ in size, 12 primary and 12 secondary, while a trace of a third series is generally apparent; a directive septum not infrequent. The septa rarely project even a short way across the aperture, but descend almost vertically from the margin, limiting a large cylindrical fossa, generally deep; a well-developed foliate convex columella, the foliæ being either thin or thick and granular, simple or divided by a directive ridge.

The interseptal loculi, seen from above, are inconspicuous and shaped like the letter W. The middle projection being caused by the rudimentary third order of septa.

The cœnenchyma on both upper and lower surfaces with a well-marked gyrating system of ridges and furrows; wherever it is growing rapidly it is spongy in texture.

This species is the most striking in the genus *Turbinaria*, and also the commonest. The calicles surpass in size those of all other Turbinarians.

\* Dana has suggested that Ehrenberg's *T. cupula* is specifically identical with *T. peltata*, while Ehrenberg's *T. peltata* is identical with his own *T. patula*. Only a reference to Ehrenberg's types could decide this. I am not myself disposed to adopt the suggestion, because firstly, Ehrenberg's description of *T. cupula* hardly corresponds with *T. peltata*; and secondly, Ehrenberg's specimens were from the Red Sea, whereas none of the numerous specimens of *T. peltata* and *T. patula* in the National Collection are recorded from any nearer locality than Mauritius. Dr. Klunzinger further found none in the Red Sea, but also apparently failed to find anything identical with Ehrenberg's *T. cupula* and *T. patula*. These species, therefore, still await identification.

The process which brings about the early obliteration of the central polyp by the cœnenchyme in young cups is often continued until the centre is convex. This leads naturally (i. e. by the flow of the nutrient fluids along the canals towards the margin) to the flat expansion of the stock as an encrusting mass. This method of growth is exemplified by several of the specimens in the Collection, notably by two magnificent almost circular stocks 4 to 5 feet across, retaining the original convex form hardly modified, exhibited in the galleries. The surface appears to die away in patches and to be grown over again.

On the other hand, the cup shape may persist, though greatly disguised by folds. These folds are very frequently of the bifrons type, i. e. they fuse back to back (Pl. VII.). When broken off, such folds appear as flat branching fragments. Two such fragments are in the Collection, one from Singapore.

Some such branching fragments (? from China Seas) probably gave rise to Dr. Verrill's species *Turbinaria dichotoma*.\* The description applies very well. The large number of septa (50 to 60) might easily be obtained by counting the rudimentary septa which appear between the 24 to 30 typically developed.

A coral from Singapore, described by Ortmann † under the name of *T. maxima*, is probably also the same.

There is a very large specimen forming an open slightly concave disc, from the surface of which a few flat protuberances rise, which appears also to belong here, but as it had already been labelled "*T. patula*," by Brüggemann, I have left it under that name. I have found it difficult to draw any sharp line between *T. peltata* and *T. patula*. In many cases, it seems that the placing of specimens in one or the other group is quite arbitrary.

The development of the cœnenchyma in the formation of these massive stocks is sometimes so great that the polyps are all immersed, and individual stocks are found in which the columella is not a continuous growth, that is, the polyps must have become detached from their columellæ in order to form new ones some millimetres above the old. In such cases, the stages in the formation of the new columella as a proliferation of the edges of the septa can be followed.

#### A. Expanded like encrusting corals (Plate VIII.).

<i>a, b.</i> King's Sound, North-West Australia.	Saville-Kent Coll.
<i>c, d, e.</i> Shark's Bay.	Saville-Kent Coll.

#### B. Cups persistent, but more or less disguised by folds (often bifrontal) (Plate VII.).

<i>g.</i> Singapore.	?
<i>h, i, j.</i> Shark's Bay.	Saville-Kent Coll.

\* 'Synopsis of Polyyps and Corals,' Proceedings of the Essex Institute, vi. (1871) p. 89. In addition to the claim embodied in Verrill's dichotomous species as to the existence of branching Turbinarians, we have also Blainville's *Gemmipora abrotonoidea*, which he places under the heading "arborescentes et partout cellulifères." This species of *Gemmipora* (= *Turbinaria*) was founded upon the *Madrepore abrotonoidea* of Quoy and Gaimard ('Voyage de l'Astrolabe,' iv. p. 232, pl. xix. figs. 1, 2); it is, however, not a Turbinarian at all, but apparently a true *Madrepore* (*vide ante*, p. 4).

† Zool. JB. Syst. Abth., iii. (1888) p. 160, pl. vi. fig. 4.



- k.* Singapore. ?
- l.* Locality not recorded.  
*(k* and *l*, 78. 6. 6. 18, 93. 4. 7. 2, are two fragments, apparently folds or branched protuberances broken off a large specimen. They are probably the same as the *T. dichotoma* of Verrill, and *T. maxima* of Ortmann.
- m.* Roebuck Bay, West Australia. Saville-Kent Coll.
- n.* King's Sound, West Australia. Saville-Kent Coll.
- C. Cups hardly modified.
- o.* ? Tonga. J. J. Lister, Esq.
- D. Tall, solid, vasiform, centre killed by deposit of sediment.
- p, q.* Mauritius.
- E. Younger cups, with margins frilled.
- r.* (With *T. speciosa*) North Australia ?
- s, t, u, v.* Shark's Bay. Saville-Kent Coll.
- w.* Malay Seas. Ex Coll. Ind. Mus.
- x, y.* Roebuck Bay, West Australia. Saville-Kent Coll.
- z.* Locality unknown. [Register No. 82. 4. 18. 2.]
- a'.* Locality unknown. [Register No. 47. 1. 19. 12.]
- F. Cups showing greater tendency to form protuberances than to frill.
- b'.* ? Singapore.
- c'.* Locality not recorded.
- d'.* (With *T. speciosa*) Port Denison. Saville-Kent Coll.
- e'.* Wide Bay, Great Barrier Reef. Saville-Kent Coll.
- f'.* Somerset, Cape York. H.M.S. 'Challenger.'
- G. Very young specimens, unmodified.
- g'.* Locality not recorded. [Register No. 82. 4. 18.]
- h'.* North-West Australia.
- i'.* Great Barrier Reef. Saville-Kent Coll.
- j', k'.* Roebuck Bay, West Australia. Saville-Kent Coll.
- l'.* King's Sound, West Australia. Saville-Kent Coll.
- m'.* (Dead) Port Denison. H.M.S. 'Alert.'
- n'.* (With *T. patula*) Great Barrier Reef. Saville-Kent Coll.

This last specimen is interesting. Two minute cups, attached side by side, but nowhere fusing, differ chiefly in the average size of the calicles. I do not think, however, that so small a difference can be considered specific. The cup with the larger calicles was labelled *T. peltata* by the late Mr. George Brook; I have provisionally labelled the other *T. patula*, the smaller size of the calicles being, according to Milne-Edwards, the chief distinguishing character. While the two species contain corals which are clearly specifically distinct, they shade off into one another so gradually that it is impossible to decide for certain whether some specimens approach more nearly the one type or the other.

Species 18. *Turbinaria patula*. (Pls. VIII. and IX. ; Pl. XXXI. fig. 16.)

*Gemmipora patula*, Dana,\* Zoophytes, 1848, p. 410.

? *Turbinaria fungiformis*, Michelin, Mag. de Zool. Classe, x. (1840) pl. i.

*Turbinaria bunkie*, Giebel, Zeitsch. Gesammt. Naturwiss., xviii. (1861) p. 134.

*Description*.—Corallum a flat disc in shape, often perfectly circular, with but slight tendency to form folds or protuberances. Margin thinner than in the last species.

Calicles generally smaller than in *T. peltata*, either immersed or the margin projects as a thick, well-marked ring of cœnenchyma. Aperture circular. The septa unequally developed; while the twelve primary are always well developed, the twelve secondary may be developed or rudimentary; when well developed the third cycle appear as rudiments. Seen from above, the septa project into the aperture more markedly than in the last species, but do not reach the half-radius circle. Seen from the side, the septa slope from the margin and then bend sharply to run down towards the columella, limiting a cylindrical or more often funnel-shaped fossa. The columella is very protuberant, sometimes standing up almost finger-like or knobbed, the knob being free of the septa. The interseptal loculi are well marked, oblong or square.

The cœnenchyma both above and below is deeply furrowed by elegantly gyrating channels, often running parallel with one another.

I am in great doubt as to the validity of this type. Although corals are included under it which differ sufficiently from *T. peltata*, they are connected with that type by numerous transition forms. The distinctions usually given, viz. the thinner margin and smaller calicles, are insufficient, in view of the great variation which exists in these respects. In the diagnosis of the species given above, I have found it necessary to lay stress upon other more important differences. But even in these, the line of distinction is not sharp; for instance, specimens of *T. peltata* occur in which the septa project far enough across the aperture as to make it almost an arbitrary matter whether they belong to the one species or to the other. The inadequacy of Dana's characters is also shown by a large specimen in the Collection which has all the characters of the calicles ascribed above to *T. patula* and which was so labelled by Brüggemann, but which has larger calicles than most *T. peltata* and a much thicker margin. On the other hand, as above stated, under this heading are grouped specimens which differ greatly from *T. peltata*, and it is they which, as it were, form the type of the species. It seems to me very probable that when our collections are more complete, the specimens now arranged under these two heads will have to be rearranged and further divided. In this case Verrill's *T. dichotoma*, Ortmann's *T. maxima*, might be revived as good species founded upon the peculiar methods of growth.

The large specimen from Sumatra, with tall, flat, narrow protuberances, belongs either here or to the last species. As above stated (p. 39), I leave it here as it was so labelled by

\* Dana suggests that Ehrenberg's *T. peltata* is synonymous. But see footnote, p. 38.



Brüggemann. The protuberances rise sharply from the surface, gradually widening as they ascend. Further, the *Turbinaria bankæ* of Giebel\* is almost certainly a young specimen of this coral.

Again, the *Turbinaria fungiformis* of Michelin and Blainville† appears to be a young form of this or of the last species, as was recognised by Brüggemann.‡

Among the specimens are a few from Torres Straits, which are of unusual interest, because they show the same form with the same eccentricity of the short stalk as do other quite different Turbinarians [*v. T. agaricia*] from the same region. The presence of these local forms of growth forces us to the conclusion that the shape of the corallum must in some way be dependent upon the environment, for here are different species, collected at different times, from the same region developing exactly the same form of corallum.

<i>a.</i> Sumatra.	Zoological Society.
<i>b.</i> Habitat unknown.	[Register No. 94. 10. 2. 1.]
<i>c.</i> Habitat unknown.	[Register No. 37. 5. 13. 64.]

Circular or oval discs.

<i>d.</i> Wednesday Island, Torres Straits.	H.M.S. 'Challenger.'
<i>e.</i> (A fragment) Torres Straits.	H.M.S. 'Challenger.'
<i>f.</i> Wednesday Island, Torres Straits.	H.M.S. 'Alert.'
<i>g.</i> Holothuria Bank, 15 fathoms.	H.M.S. 'Penguin.'
<i>h.</i> Habitat unknown.	G. B. Sowerby, Esq.
<i>i, j.</i> Gulf of Carpentaria.	Saville-Kent Coll.

Young cups or discs.

<i>k.</i> Wednesday Island, Torres Straits.	H.M.S. 'Challenger.'
<i>l.</i> Habitat unknown.	[Register No. 93. 7. 1. 3.]
<i>m.</i> Holothuria Bank, North-West Australia.	H.M.S. 'Penguin.'
<i>n.</i> Great Barrier Reef.	Saville-Kent Coll.
<i>o.</i> (With <i>T. aurantiaca</i> , Port Denison.)	Saville-Kent Coll.
<i>p.</i> Torres Straits West.	Prof. A. C. Haddon.

Youngest specimen with another, with somewhat larger calicles (see p. 40, *n'*).

<i>q.</i> (With <i>T. peltata</i> , Great Barrier Reef.)	Saville-Kent Coll.
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Two much-perforated fragments from Wednesday Island, Torres Straits, collected by the 'Challenger' expedition, have been labelled by Quelch as dead portions of *Turbinaria patula*. They have a strong resemblance to the dead portions of the living specimen (*d*) gathered at the same time.

*r.* (Two worn fragments) Wednesday Island, Torres Straits.

\* Zeitschr. f. d. Gesammt. Naturwiss., xviii. (1861) p. 134.

† Guérin's Mag. de Zool. Classe, x. (1840) pl. 1.

‡ Ann. and Mag. of Nat. Hist., xix. (1877) p. 47.

Species 19. *Turbinaria orbicularis*. (Pl. XXXI. fig. 17.)

*Description*.—Corallum peltate, slightly concave in the centre, while the edges grow out horizontally. Edge of corallum thin, composed of a row of budding calicles. It is consequently deeply wrinkled on the under surface for about half an inch.

Calicles large (3 mm.), though varying in size, the margin only protuberant as thin elliptical rings about 1 mm. high. The rather solid cœnenchyma of the outer layer of this wall changes suddenly into the ring of short, thin septa. The number of these depends upon the size of the calicle, the largest having 34 to 40, the smaller, 24. They fall far short of the half-radius circle, and slope gradually down round the deep, open, slightly funnel-shaped fossa. The columella is very conspicuous and protuberant, almost ball-like.

The cœnenchyma is a rather coarse, solid reticulum, tending here and there to form a typical ridge-and-furrow system.

There are three specimens, perhaps too young to classify, which I have associated together under this heading. Their edges have unfortunately been much broken owing to their thinness. The largest appears originally to have been a circular plate, 10 cm. across, with a slight depression immediately above the short, thick stalk. One of the smaller specimens (6 cm.) has a thinner stalk, but otherwise agrees in almost all essentials with the type. The other shows a slight tendency of the margin to fold, and may be a young specimen of *T. conspicua*. The most conspicuous differences between the specimens is in the fine texture of the columella. In the largest specimen the columella becomes granular, whereas in the smaller it remains foliate, in some cases with a peculiar twist in it as if it had been stirred round, which is probably another expression of the tendency to a spiral twist noticed in the introduction (p. 13).

The central calicles in the larger specimens are immersed, and face directly upwards; the outward slope commences near the edge along which the young calicles are budding quite horizontally. This species thus affords an excellent illustration of the bending up of the calicles as they grow, in order to allow the next buds to continue in approximately the same plane of growth.

One edge of the larger specimen has been greatly distorted by Balanids.

- |   |                            |
|---|----------------------------|
| <i>a.</i> King's Sound, West Australia. | Saville-Kent Coll. (Type.) |
| <i>b.</i> King's Sound, West Australia. | Saville-Kent Coll.         |
| <i>c.</i> Somerset Shore, Cape York.    | H.M.S. 'Challenger.'       |

Species 20. *Turbinaria radicalis*. (Pl. IX.; Pl. XXXI. fig. 18.)

*Description*.—Corallum a flat circular disc, with slight tendency to form protuberances. As it spreads over the substratum, it sends down finger-shaped processes like roots, which may secondarily branch. These become attached to the substratum. Free margin of the disc thin.

Calicles crowded, projecting as blunt cones in parts, especially on slight elevations. Apertures circular or slightly elliptical (2 mm. and under). Septa (16, here and there 24) project to about the half-radius circle; in the projecting calicles the upper edges of the septa



run back a short way beyond the margin of the aperture into the ridges of the cœnenchyma. Septa descend slantingly from the margin, and then bend round to bound a short cylindrical fossa. Owing to the slope of the septa, the fossæ are funnel-shaped, with a short cylindrical basal portion. Columella prominent and oval, with a marked directive keel. Interseptal loculi well marked, broad or narrow wedge-shaped according to the number of septa, in the smaller calicles often petaloid, in the projecting calicles often sharply marked off peripherally by the sudden ending of a ridge of the cœnenchyma.

Cœnenchyma finely granular, ridge-and-furrow system visible with pocket-lens, most marked on the projecting calicles.

There are two specimens of this singular Turbinarian, both almost perfect discs, one 9 cm. in diameter, with an irregular surface, and a young specimen 4.5 cm. in diameter, perfectly flat. There is no visible stalk, the centre of the under surface of the disc being in contact with a conglomerate mass forming the substratum. This mass is clasped at its edges by the root-like processes which suggested the specific name. These root processes are but variations of the flowings of the cœnenchyma which ordinarily thicken the stalk. The flat disc shape of the corallum in this case has something to do with the production of these roots, which, in the larger specimen, hang free of the substratum. There is not sufficient slope to cause the fluids to run in towards the centre. Hence, on reaching the epithecal film\* which spreads outwards from beneath the centre of the disc, where it is in contact with the substratum, it drops to form the rootlets above described, which may fork at their tips as if seeking attachment.

The younger specimen differs slightly in the character of the calicles from the larger; the disc is, in the former case, very thin, so that the calicles, which do not project, are very shallow. This makes the oval columella appear much more prominent than is the case in the older and thicker stock with deeper calicles.

*a, b.* Great Barrier Reef.

Saville-Kent Coll. (Type.)

Species 21. *Turbinaria agaricia*. (Pl. IX.; Pl. XXXI. fig. 19.)

*Description*.—Corallum shield-shaped, round or oval, slightly concave; stalk short, thick, eccentric; margin thin, slightly and irregularly waved. Under side wrinkled.

Calicles slightly and evenly protuberant, except in the base of the concavity where they are immersed; slope slightly outwards, i. e. towards the growing edge. In some specimens smaller and more crowded than in others. Margin of the protuberant aperture of irregular thickness, often thicker on dorsal than on ventral side. Aperture round or elliptical, nearly uniform in size on the same specimen, but differing on different specimens from 1.25 mm. to 2 mm. in diameter. Eighteen to twenty-four septa, which do not reach the half-radius circle, bend round from the margin and slope downwards to form a cylindrical or slightly funnel-shaped fossa. The septa may be thick and granular if the ridges of the cœnenchyma

\* This secondary epitheca is not infrequent on the under surfaces of Turbinarians, and seems to prepare the way for the attachments of innumerable organisms (see *ante*, p. 11).

are so. The columella (sometimes indistinct) irregularly oval, protuberant, granular, and very solid looking.

The interseptal loculi vary according to the character of the septa and cœnenchyma.

The cœnenchyma is in section very dense. The surface marking varies greatly, the ridges are thick, granular, and very solid looking, or broken up into solid granules.

The specimens associated under this name afford an excellent example of the amount of variation which may occur in the character of the calicles. There are four, collected at the same time, in the same place, and three of them growing exactly alike (the fourth is only a fragment), and yet in all four cases the calicles differ greatly in almost all exact characters. The calicles agree only in the amount of protuberance, whereas in size of aperture, in degree of crowding, in number of septa, in shape and depth of the fossa, and in distinctness of the columella, no two are alike. While agreeing again in the density of the cœnenchyma in section, which is a mechanical necessity, owing to the horizontal growth of the thin corallum, they differ entirely in the characters of the surface markings.

This case brings us face to face with the question, "which characters are most important in determining relationship, the method of growth, or the shape of the individual calicles?" One would think it very unlikely that these specimens should owe the exact similarity of their forms to the influence of the environment, which is never quite uniform over any large area. The form depends upon the budding, i. e. upon processes somewhat withdrawn from immediate contact with the surrounding medium. The polyps, on the other hand, which determine the character of the calicle, are in constant and immediate contact with the external world, and react to all the variations in the environment.

But there happen to be specimens of *T. patula* from the Torres Straits showing exactly the same form of corallum, with the same eccentricity of the stalk, which proves that at least in this region the environment must exercise a powerful influence on the forms of the coralla. In this case, then, all our characters break down. The only character uniting the specimens appears to be due to the environment. There seems to be but one alternative to the provisional classification here adopted, viz. to attempt to distribute the specimens under other headings according to the characters of their calicles. In view of the enormous amount of variation in the calicles on one and the same corallum, such a task appears from our present standpoint almost superhuman (*vide* Introduction, p. 19.)

The specific name is adopted from the generic name *agaricia*, the typical form of which is not unlike that of these specimens.

The largest is 17 cm. in longest diameter, and is chosen as the type specimen.

*a-c.* Torres Straits West.

Prof. A. C. Haddon.

*d.* (a fragment).

Prof. A. C. Haddon.

A very minute specimen, 1 cm. high and 2 cm. in diameter, and labelled tentatively "*T. brassica*(?) Dana," may perhaps belong here. It is decidedly peltate. But it is impossible to say to which of the peltate species it belongs, or whether it is the young of an unknown form.

*a.* Habitat unknown.

Lords of the Admiralty. 59. 2. 25. 7.



## Group III.—TURBINARIÆ FRONDENTES.

*Specimens in which the nearly perpendicular edge of the deep bowl-shaped cup increases in circumference by forming lobes, which may curl inwards round vertical axes (Dana's "cucullate infolding").*

Species 22. *Turbinaria frondens*.

*Gemmipora frondens*, Dana, Zoophytes, 1848, p. 412, pl. 27, fig. 10.

*Turbinaria frondescens*,\* Milne-Edwards and Haime, Les Coralliaires, iii. (1860) p. 167.

*Description*.—Corallum consists of thin erect leaves, here and there lobed, not externally wrinkled.

The calicles are crowded, projecting, either subcylindrical or on rounded conical eminences, the aperture from 1 to 1.33 mm. in diameter. Septa 17, fossa deep, cœnenchyma irregular, ridge-and-furrow system.

In addition to his description of the corallum, Dana gives a coloured figure of a single polyp, with 17 yellow, half contracted tentacles around a green oral disc, the actual edge of the oral aperture being also yellow; the skin of the corallum appears of a reddish-brown colour.

This species is represented in the National Collection merely by one small fragment labelled *T. frondens* by Brüggemann, which may be a portion of a larger growth, but it does not show the projecting calicles of Dana's figure.

Dana's specimens were from the Fiji Islands.

*a.* Samoa Island.

Rev. S. J. Whitmee.

Species 23. *Turbinaria brassica*.

*Gemmipora brassica*, Dana, Zoophytes, 1848, p. 413, pl. 29, fig. 1.

*Description*.—Fronds erect, very thin and curled round vertical axes ("cucullately infolded"), exterior wrinkled.

Calicles not crowded, projecting "conico-cylindrically," 1.25 mm. in diameter. Septa, according to Dana's figures, 20 to 30, hardly projecting from the margin, and limiting a large, circular, shallow fossa, the walls of which slope slightly inwards towards a well-marked convex columella.

There is no specimen in the National Collection corresponding with this description.

Habitat, Fiji Islands.

\* The specific name is given as *T. frondescens*, but this is apparently a clerical error for "*frondens*."

Species 24. *Turbinaria auricularis*. (Pl. X.; Pl. XXXI. fig. 20.)

*Description*.—Large open cup with thin, nearly erect walls, from which accessory lobes rise and curl round vertical axes, forming secondary incomplete cups within the cavity of the original.

Calicles, somewhat close together in irregular concentric rows which are rather far apart, project as slight conical or rounded bulgings of the cœnenchyma. The aperture circular or oval, occupying the whole top of the eminence, varies from 1.5 to 2.5 mm. in diameter. Septa (16 to 24), beset with fine granules, seen from above, project evenly to the half-radius circle; seen laterally, they slope gradually downwards and then bend sharply to descend vertically to the columella. The fossa is shallow but well marked, cylindrical or oval. The columella appears to be formed of a row of transverse granular plates, sometimes joined along their centres by a directive keel.

The interseptal loculi are narrow, but well marked, and owing to the fineness of the surface structure of the cœnenchyma, appear to be well marked peripherally.

The cœnenchyma appears to the naked eye nearly smooth, but is rough to the touch; and a pocket-lens shows a typical ridge-and-furrow system largely broken up into series of fine granules or points.

The single specimen here described seems to have hung from the side of some object. The bottom of the cup is smooth and round like that of a soup-ladle, and there is no trace of a stalk. The interior of the cup has been influenced in its growth by the deposition of a mass of sediment. It was, however, in vigorous growth when collected, and the characters are perfectly normal.

The specific name was suggested by the ear-shaped (or spoon-shaped) accessory fronds which develop within the original cup. They make it probable that the young form of the cup was such an ear-shaped frond attached to the side of some object.

*a.* Ponapé. (Type.)

Species 25. *Turbinaria calicularis*. (Pl. XI.; Pl. XXXII. fig. 1.)

*Turbinaria crater*, Quelch (partim), Chal. Rep. Cor., 1886, p. 166.

*Description*.—Corallum cup-shaped, with short indistinct stalk, margin not very thin, where broken (i. e. interrupted by foreign bodies) folding round vertical axes.

Calicles somewhat crowded in concentric lines, which are, however, not very close together, projecting on blunt cones (2 mm. high and under); apertures circular, hardly occupying the whole top of the eminence (2 mm. to less than 1 mm. in diameter). Septa (mostly 13) thick at the margin and well marked, but not reaching to the half-radius circle, descending vertically round a rather deep cylindrical fossa; columella hardly protuberant.

Interseptal loculi irregularly rounded peripherally, so as to be short petaloid.

Cœnenchyma both inside and outside like fine sandpaper.



The single specimen has not developed far enough to reveal for certain its typical method of growth. But for its close resemblance in many respects to the last and to the next species, and for the peculiar curling of the margin where it has been notched, it might have been placed among the crateriform Turbinarians. It was indeed labelled *T. crater* by Quelch.

I have named the species from the shape of the specimen in the Collection. Perhaps a larger specimen, revealing its typical method of growth, might render the name unsuitable, as the bowl shape which is the early stage of the corallum need not be persistent.

*a.* Amboyna.

H.M.S. 'Challenger.' (Type.)

Species 26. *Turbinaria porcellanea*. (Pl. XXXII. fig. 2.)

*Description.* — [Whole corallum unknown.] Fronds thin and delicate, the growing margin 1 mm. thick, increasing below to 3 mm., externally not markedly wrinkled.

Calicles not crowded, the concentric rows far apart on slight bulgings of the cœnenchyma, the margin not projecting, aperture circular (diameter 1.5 mm. and under). Septa (13 to 18) reaching to the half-radius circle, bending gradually over from the margin to descend perpendicularly to form together the shallow cylindrical fossa. Columella conspicuous, as three or four transverse granulated lamellæ protruding upwards from the floor of the fossa.

Interseptal loculi not sharply or regularly bounded peripherally, but tending to be petaloid.

Cœnenchyma inside like fine yellow sandpaper, outside like finely grained white porcelain. In section the yellowish colour is seen to extend to the layer formed by the confluent polyp-cavities, outside which the cœnenchyma is white and comparatively solid.

There is only a single frond (in four fragments) of this interesting species, which differs markedly from all the preceding. The name is suggested by the curious porcelain-like outer layer of the cœnenchyma, which is, as far as we know, unique among the Turbinarians. I associate it with *T. auricularis* and *T. calicularis* on account of its similarity to them in superficial characters, such as the general resemblance of calicles and cœnenchyma.

*a.* (In four fragments) Treasury Island, Solomon Islands.

Dr. Guppy. (Type.)

Group IV.—TURBINARIÆ FOLIATÆ.

*Turbinarians whose adult stocks are composed of sinuous fronds, more or less erect, and fusing together irregularly.*

Species 27. *Turbinaria magna*. (Pls. XIV., XV.; Pl. XXXII. fig. 3.)

*Turbinaria crater*, Quelch (partim), Chal. Rep. Cor., 1886, p. 166.

*Description.*—Corallum composed of more or less erect fronds (not lobed) either closely or openly sinuous, forming also tall cylinders open or closed at the top, or digitiform processes. Depth of living zone of frond may be 20 cm. and more, hence corallum often towers upwards. Fronds, when thin, much wrinkled externally.

Calicles may be very prominent on cylindrical or protuberant portions of the stock, but on the faces of the fronds hardly projecting or with only the margin projecting, or again, only the dorsal margin standing out so as to allow the calicles to look somewhat upwards. Aperture oval, great variation in length of long diameter (from ca. 3 mm. max.). Septa (20) thick and regular, not reaching to the half-radius circle, descending more or less abruptly and vertically round a generally deep oval fossa with a well-marked columella. The interseptal loculi short-oblong, with well-defined peripheral margins.

Cœnenchyma thick, granular or echinulate; ridges well developed and of regular thickness, separated by deep furrows.

The diversity in the appearance of these corals is so great, that, but for the fact that they are connected together by intermediate forms, they would certainly be made to yield three or four species. An encrusting mass throwing up four or five tall cylinders would not be classed either with another sending up a confused mass of finger-like processes, or with a mass of erect and sinuous fronds. Yet all these diversities occur, but fortunately linked together by forms showing more than one method of growth in one and the same stock.

The variations in the sizes of the calicles are also very great. One cylinder will be covered with minute calicles, another near at hand, on the same stock, with large calicles.

One remarkable feature is the great similarity between this species and *T. conspicua* in the character of the calicles and of the cœnenchyma; so like, indeed, are they, that it is probable some of the many young forms which I have labelled *T. conspicua* may well be the early cups of *T. magna*, it being impossible to say into which form they might develope.

*T. magna*, however, seldom if ever develops the bifrons type of fold, and *T. conspicua* does so almost without variation. Had there been any variation in *T. conspicua* showing the formation of fronds without the bifrons folding, the two species would have shaded off into one another.

A remarkable variation is found in the arrangement of the fronds in the more foliate specimens. The fronds in some are so arranged that the polyp-bearing faces are all exposed to the view, the under faces (free from polyps) being apposed and inconspicuous. In others, the reverse is the case: the bare under surfaces form great open hollows and valleys, while the polyp-bearing faces are so close (even fusing) as to be quite inconspicuous. These two strikingly different methods of growth are connected by intermediate stages, so that they have to be looked upon as accidental and of no specific value.

The old parts of the fronds and cylinders die away, and a wide living zone persists, forming along its lower edge a slight shelf, as if trying to curl up.

Most of the specimens are much infested by a species of *Balanus*.

The name was suggested by the large size of some of the more conspicuous fronds, which give these particular stocks a very imposing appearance.

A. Masses of irregular fronds with occasional formation of protuberances and cylinders; upper faces of fronds most conspicuous.

a. Shark's Bay (with *T. conspicua*).

Saville-Kent Coll. [94. 3. 9. 4.] (Type.)

b-c. Shark's Bay (with *T. conspicua*).

Saville-Kent Coll.

f. (A fragment) Wednesday Island, Torres Straits, 8 fathoms.

H.M.S. 'Challenger.'



## B. Foliate, with under sides of fronds most conspicuous.

g. Shark's Bay (with *T. conspicua*).

Saville-Kent Coll.

h. Shark's Bay (with *T. conspicua*).

Saville-Kent Coll.

(This latter (*h*) ought perhaps to be classed separately.)

## C. Encrusting masses, throwing up massive cylinders or protuberances (Plate XV.)

i, j. Shark's Bay.

Saville-Kent Coll.

## D. A single fragment of a cylinder forming at the top a gracefully gyrating frond.

k. Shark's Bay.

Saville-Kent Coll.

## E. Irregular masses of fronds, thin finger-like processes, &amp;c.

l, m. Shark's Bay, West Australia.

Saville-Kent Coll.

## F. Two fragments of fronds which may belong here.

n. Green Island, Great Barrier Reef.

Saville-Kent Coll.

o. Great Barrier Reef.

Saville-Kent Coll.

G. Two large cups which, from the character of the calicles, may be young specimens of *T. magna*, not yet showing the irregular growth.

p. Great Barrier Reef.

Saville-Kent Coll.

q. Port Denison, Queensland.

Saville-Kent Coll.

## H. A large stalked cup, with edges thrown up into great folds, showing the method of modification of the early cup stage. (Plate XIV.)

r. Gulf of Carpentaria.

Saville-Kent Coll.

Species 28. *Turbinaria irregularis*. (Pl. XII.; Pl. XXXII. fig. 4.)

*Description*.—Corallum a mass of gyrating fronds, wrinkled on the outside, seldom more than 5–6 cm. deep. Hence the stock does not tower like the last. The fronds frequently fuse face to face, the under sides being the more conspicuous, forming open funnels and valleys. The stock may also form encrusting masses with protuberances and cylinders.

The calicles, round and small (apertures 1·5 mm.) and inconspicuous on the fronds, large (3 mm.) and projecting on the protuberances. The septa (ca. 18 in the small, 28 to 30 in the large calicles) are conspicuous, although at the aperture they do not reach the half-radius circle. They commence almost at once to descend round a large circular fossa, curving inwards near the bottom towards the spongy columella. This is mostly flat or even concave, in which case the fossa is like a deep bowl.

The interseptal loculi very inconspicuous round the margin of the calicles, but show as deep oval holes all round the columella.

The cœnenchyma is spongy or reticulate on both upper and lower surfaces, without any

conspicuous development of the ridge-and-furrow system. The reticulum may be composed of threads or bands.

Owing to the small depth of the fronds, the stocks do not rise to any height, but spread laterally, the dead portions being grown over by new fronds.

There are four specimens which appear to belong together, although there is some doubt as to whether they might not be divided into two species.

The specimens *c* and *d* differ slightly from the type. In the former (*c*) individual calicles project to a great height and then bend, giving rise to a secondary polyp; further, whereas the margins of the calicles in the type are sharp and clearly defined, the reticulate structure of the cœnenchyma being very fine, in this specimen the reticulum of the cœnenchyma is coarse, and the thin margins easily crumble away.

The specimen (*d*) is a small nodule with the same character of calicle, but with the reticulum of the cœnenchyma very massive and close, the nodule being almost like a solid stone.

There is another specimen (from Diego Garcia, now labelled *T. globularis*) which resembles this species in general characters of the calicles, but it is a large globular mass, and has, for the sake of consistency, been transposed to the glomerate group. Its resemblance to *T. irregularis*, which here and there forms encrusting nodules among the fronds, combined with the fact that other glomerate specimens bear a close resemblance to certain other types, inclined me at first to believe that all the glomerate Turbinarians were but accidental massive varieties. It is quite possible that such massive varieties may occur, but the evidence in favour of a distinct glomerate type of growth compels us to place all globular forms apart, unless we have clear proof that any particular specimen is such an accidental variety.

The specific name *irregularis* was suggested by the remarkable fact that the fronds fuse face to face, which must involve the continual destruction of the polyps. This deliberate sacrifice of a percentage of the individuals does not, however, affect the vigorous growth of the colony as a whole.

*a.* Mauritius.

(Type.)

*b.* Mauritius.

*c, d.* Locality not recorded.

[Register Nos. 93. 7. 1. 7; 96. 2. 11. 1.]

Species 29. *Turbinaria robusta*. (Pl. XI.; Pl. XXXII. fig. 5.)

*Description*.—Fronds more or less erect, deep, upper edge freely bent, often wavy, and not crowded, frequently fused back to back, forming tall flat processes, or else hollow cylinders. Margin stout, about 4 mm., with conspicuous row of large round calicles developing along the edge.

Calicles tall, barrel-shaped, projecting on prominences; but on the fronds, the aperture only projects so as to look outwards and upwards; the ventral edge is, however, raised somewhat above the cœnenchyma.

The aperture is round or round-oval, or at times almost oblong, surrounded by a thick margin. The septa (20 to 24) are either suddenly differentiated out of the margin as thin lamellæ, or only gradually, and, seen from above, are then wedge-shaped. They do not reach



the half-radius circle. They slope down at once to descend perpendicularly round the large elliptical fossa (1.5 to 2 mm. in long diameter). The columella is a light spongy mass, with or without a directive keel.

The interseptal loculi are, as a rule, irregular gashes in the thick margin round the aperture.

The ridge-and-furrow system of the cœenchyma is generally well marked, but the ridges are thin and delicate, sometimes broken up into points, giving the outside a velvety appearance. On the upper surface, the ridge-and-furrow system is very pronounced round the projecting calices.

I have chosen as the type specimen a large, almost circular cup, partly because it shows nearly all the varieties of growth of the group, but chiefly because it is the most perfect specimen. All the older growths in which the primitive cup has been entirely lost are but fragments.

Some of these fragments were living growths, developing along the edges of dead fronds. One case is especially interesting (*j*) [Register No. 46. 7. 30. 37], as the dead portion is the original stalked cup, while the living, folded portion has grown from its edge, spreading backwards, covering one half of the original cup with a new growth (cf. paragraph on progressive dying and periodical growth, Introduction, p. 12).

As might be expected, great variety of form and appearance prevails among these fragmentary specimens. In some fragments, the tall, barrel-shaped calices predominate, owing to the special growth of the portion collected; others, again, are simple fronds, with calices hardly projecting at all. It is, indeed, only by the presence of stocks showing both styles of growth that we are enabled to class them together.

<i>a.</i> Port Denison, Queensland.	Saville-Kent Coll. (Type.)
<i>b-c.</i> Torres Straits (West).	Prof. A. C. Haddon.
<i>d.</i> Gulf of Carpentaria.	Saville-Kent Coll.
<i>e-h.</i> Great Barrier Reef.	Saville-Kent Coll.
<i>i.</i> North Australia.	J. R. Elsey, Esq.
<i>j.</i> Port Essington.	J. B. Jukes, Esq.
<i>k.</i> North-East Australia.	H.M.S. 'Alert.'

Four quite young cups which may belong here or to *T. magna*.

<i>l-o.</i> Great Barrier Reef.	Saville-Kent Coll. 92. 12. 1.	$\left\{ \begin{array}{l} 656. \\ 669. \\ 672. \\ 674. \end{array} \right.$
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Species 30. *Turbinaria pulcherrima*. (Pl. XI.; Pl. XXXII. fig. 6.)

*Description*.—Corallum a mass of gyrating fronds, with very undulating edges, slightly bent outwards, fronds not deep, ca. 5 cm.

Calices on slight eminences of the cœenchyme. The apertures elliptical (sometimes oblong) 2 mm. in long diameter, the smaller ones star-shaped. Septa 20 and under, do not, at the aperture, reach the half-radius circle, but slope inwards, bounding a somewhat funnel-shaped fossa, from the base of which a narrow, oval, spongy columella without directive keel protrudes.

Interseptal loculi very pronounced, petaloid in the smaller star-shaped calicles (with 14 septa) but wedge-shaped in the large calicles (with 20 septa).

Cœnenchyma a fine velvet-like reticulum, of a beautiful grey colour, system of ridges and furrows running in the line of growth, the ridges being fine and saw-like.

These specimens are interesting because, in the general character of the cœnenchyma, they strongly resemble other Turbinarians from the same locality, and thus exemplify what was stated in the Introduction, that the different species of Turbinarians, in each locality, acquire a sort of complexion which appears to be peculiar to that locality.

This species may be the same as the next, *T. crispa*, as its growth appears to be the same. The difference in the calicles may be of secondary importance.

*a.* Tongatabu.  
*b-d.* Tongatabu.

J. J. Lister, Esq. (Type.)  
J. J. Lister, Esq.

#### Species 31. *Turbinaria crispa*.

*Turbinaria crispa*, Rehberg, Abh. Naturwiss. Ver. Hamburg, xii. (1892) p. 44.

This species, described by Rehberg as apparently one of the commonest in the Tonga Islands, may be the same as that just described. The following diagnosis, gathered from Rehberg's description, differs sufficiently from the account of *T. pulcherrima* to justify their separation, until a closer comparison establishes their specific identity.

*Description*.—Corallum, a labyrinth of erect, gyrating fronds, forming cylinders, &c. The fronds retain throughout the same thickness (hardly 3 mm.).

The calicles with small apertures, 2 (rarely 3) mm. broad, projecting some 3 mm., the base of the eminence being about 4 mm. across. Septa 14 and more, small columella. Cœnenchyma is beset with spongy plates, arranged in gyrating rows or with echinulæ.

Rehberg had several examples of this coral 40 cm. in circumference and 30 cm. high.

From this description, we see that the calicles are more prominent than in *T. pulcherrima*, although the number of septa appears fairly well to agree. The great height of the stock, as compared with its circumference, leads one also to conclude that the fronds of *T. crispa* are much deeper than are those of *T. pulcherrima*.

The grey colour of the coral mentioned by Rehberg, and the character of the cœnenchyma, is another example of the similarity of the Tonga Islands *Turbinariæ* in these points.

#### Species 32. *Turbinaria sinensis*.

*Turbinaria sinensis*, Verrill, Proc. Essex Institute, v. (1866) p. 27.

*Description*.—Corallum "crateriform," large, thick and firm, attached by a short, thick peduncle.

Calicles moderately large (ca. 2 mm. in diameter) rather crowded, somewhat in transverse and concentric series, standing, except near the edge, almost at right angles, but projecting only slightly above the surface, somewhat swollen at the base. Septa subequal,



narrow in three cycles, some of the third cycle wanting except in larger calices when some of the fourth appear; the fossæ very deep, columella reduced.

Cœnenchyma loosely porous and spongy. Under surface even, uniformly covered with loose, irregular papillæ, with large irregular pores below.

This type, thus described by Verrill, is from Hong Kong and the China Sea. There are no crateriform corals in the Collection closely resembling it. But certain foliate stocks from Formosa were classified under this name by Brüggemann. While the foliate Turbinarians doubtless start life as cups, and individuals may persist as such until they are a great size, it is perhaps somewhat daring to connect foliate stocks with the descriptions of large crateriform stocks without possessing for close comparison a complete series. Nevertheless, I am inclined to think that Brüggemann's instinct led him right, at least in regard to two specimens. The fronds in these cases are thick, and though one is wholly foliate, the smaller one is still traceable to a cup with a short thick peduncle.

Other characters also appear to agree very well with Verrill's type. Hence it is difficult to give any reason, in the absence of actual evidence, why these should not be the later growths of a crateriform stock similar to that described by Verrill.

While, therefore, for practical purposes, Brüggemann's identification is accepted, it is well to point out possible objections. (1) Verrill's cup was very large, 14 inches wide, 10 high, which would be, I should think, unusual in a stock whose typical method of growth was foliate with fronds not much more, generally less, than 4 inches deep. (2) The character of the cœnenchyma cannot be relied upon, as all the corals from the China Seas appear to resemble one another just as do those from Tongatabu and those from Shark's Bay, in this respect.

For further identification, then, it will be well to add that in Brüggemann's larger specimen, the fossa is slightly funnel-shaped, and like the aperture, generally circular. Nevertheless, in the shallower calices near the growing margin, the columella is a small but distinct, prominent, oval mass, seen under the glass to be composed of irregular granules, not visibly joined to form a sponge-work. The interseptal loculi are broad and sufficiently pronounced to give the apertures a star-like appearance, and except near the growing margin are more or less sharply bounded peripherally, that is, they do not run into furrows or fissures in the cœnenchyma surrounding the calicle. The septa slope downwards, almost immediately bending round with a sharp curve or with an angle to form together the fossa. The growing edges of the fronds show a slight tendency to bend outwards and to have a wavy outline; neither of these points, however, being so marked as in *T. pulcherrima*.

In addition to the two specimens identified by Brüggemann is another which bears a sufficiently close resemblance to the smaller of these two to be classed with it, although collected from a different region. It is merely a fragment of an old stock and consists chiefly of short thick cylinders.

*a, b.* Formosa.

Swinhoe Coll.

*c.* Rocky Island, Great Barrier Reef.

Saville-Kent Coll.

Species 33. *Turbinaria tubifera*. (Pl. XIII.; Pl. XXXII. fig. 7.)

*Description*.—Corallum a mass of more or less erect fronds 8 to 10 cm. deep, very much folded, but not densely crowded, forming many open cylinders and funnels; the cylinders may put out smaller lateral cylinders. Margin thick, wavy, not bent outwards.

Calicles somewhat crowded, slightly but very regularly projecting, almost as hemispheres (3 mm. diameter). Apertures (1 mm.) round, filling the whole top of the projection. Septa (about 20) seen from above appear to project beyond the half-radius circle, but really slope gradually down from the margin to this point and then descend vertically round a small clearly marked oval fossa. Columella long-oval, often showing a very prominent directive keel. The interseptal loculi are very marked, as long gashes in the circular margin continuous with the fine open meshwork of the cœnenchyma.

The cœnenchyma is a very fine spongy mass, showing, however, under the glass, especially on the outer surface, a delicate ridge-and-furrow system. On the upper surface these gyrate, but on the lower they tend to run in the line of growth.

The single specimen is part of an old stock and shows the typical method of growth; the calicles are unlike those of any other Turbinarian in the Collection. At the same time, it has a very similar general appearance to other Turbinarians from the same locality. But as we have seen, this similarity is very delusive, being due to the action of the environment and not to any close relationship. The specimen was, apparently on account of this resemblance, classed by Brüggemann with *T. sinensis*. The specific name refers to the number of open cylinders which characterise the stock. The method of formation of the cylinders reminds one of the mesenteriform type of growth, but it is too irregular in this case.

*a. Formosa.*

Swinhoe Coll. (Type.)

Species 34. *Turbinaria venusta*. (Pl. XI.; Pl. XXXII. fig. 8.)

*Description.*—Corallum a mass of erect fronds, not thick, nor crowded, 6 to 8 cm. deep, slightly wrinkled, not wavy along the margin.

Calicles projecting as thin cylinders up to 3 mm. high, nearly at right angles to the cœnenchyma. The rounded tips of the projection fully occupied by the oval apertures (ca. 2 mm.) The septa (about 16) project beyond the half-radius circle, and bend round immediately to descend vertically round a deep oval fossa. Columella protuberant as a long oval mass of irregular granules. Interseptal loculi narrow and long, not marked off peripherally, often like gashes cut down deep in the oval wall of the projecting calicle.

Cœnenchyma on the upper surface punctate, showing only the tips of closely crowded granular projections. On the outside, near the margin, these are less crowded and the pores can be seen between; this character passes towards the base of the frond into a typical ridge-and-furrow system, which gradually becomes dense and stony by the thickening and smoothing of the ridges.

I at first gave the specific name *venusta* to a small and very beautiful cup which appeared to stand alone in the Collection. The resemblance in general characters between this cup and the fragment of the larger foliate corallum above described, seemed, however, to justify their being provisionally classed together. The small cup differs chiefly in the more coarsely granular character of the cœnenchyma, which, as usual, affects the thickness of the septa and the general appearance of the aperture. The calicles, further, do not seem to project so markedly. The septa average 18–20, i. e. more than in the older specimen.



It is of course impossible definitely to assert the specific relationship between the two until we have more specimens showing the intermediate stages of growth. But it is very probable that the small cup is the young stage of the foliate specimen.

- |  |   |
|--|---|
| <p><i>a.</i> Great Barrier Reef.<br/> <i>b.</i> Locality not recorded. (Cup specimen.)</p> | <p>Saville-Kent Coll. (Type.)<br/>         [Register No. 93. 7. 1. 11.]</p> |
|--|---|

Species 35. *Turbinaria aspera*.<sup>\*</sup> (Pl. XV. ; Pl. XXXII. fig. 9.)

*Description*.—Corallum composed of irregularly arranged, much twisted fronds, thin, brittle-looking, shallow (3–4 cm.). The thin growing edge alternately swelled by the budding calicles and constricted between them; the young calicles are deep, round or fusiform pits. The edge tends to turn up at the tips, but down at the sides of lobate fronds as in the mesenteriform type of growth.

The calicles sparse, the thin walls projecting sharp and clear from the level coenenchyma or from the top of blunt eminences; nearly regularly circular (ca. 2 mm.). Septa, about 20, very inconspicuous, merely ridges round the large cylindrical fossa. Columella large, flat or only slightly protuberant, a rather compact mass of granules. Interseptal loculi broad notches in the thin wall of the calicle here and there, when closed peripherally, bulging the wall outwards. Fractures revealing sections of the calicles show that, below the margin, interseptal loculi are much longer, forming a circle of large rays round the columella.

Coenenchyma very rough and harsh to the touch, the ridges broken up into pronounced granules, but still preserving the ridge-and-furrow system, which shows a tendency to run spirally up the slopes of the calicles.

I have named this coral after its roughness, the idea being probably as much due to its appearance as to the harshness of the touch, which is a character common to nearly all Turbinarians.

The type specimen is a fragment of a larger stock and hence may be relied upon to show the typical manner of growth. As is frequent with foliate stocks, this approaches in some ways the mesenteriform type of growth, but it appears to be too irregularly foliate to come into the mesenteriform group.

- |  |   |
|--|---|
| <p><i>a.</i> Habitat unknown.<br/> <i>b, c.</i> Habitat unknown.<br/> <i>d.</i> Red Sea.</p> | <p>[Register No. 93. 7. 1. 13.] (Type.)<br/>         [Register No. 93. 7. 1. 14–15.]<br/>         [40. 5. 7. 32.]</p> |
|--|---|

<sup>\*</sup> There is no fear of confusing this name with the fossil *Gemmipora asperrima* of Michelin (Icon. Zoophyt., p. 163, pl. xlv. fig. 5). It is indeed doubtful whether this was a Turbinarian at all, the calicles being wide of the Turbinarian type. On the other hand, the coral above described may be related to the fossil cup, *Gemmipora (Turbinaria) cyathiformis*, Blainville (see Michelin, l.c. p. 65, pl. xiii. fig. 8) which has the same hard sharp edges to the calicles, and the spiral twist of the ridges on the coenenchyma, although the twist is not peculiar to this species.

Species 36. *Turbinaria gemmulata*.

*Turbinaria gemmulata*, Verrill, Appendix to Dana's Corals and Coral Islands, 1st edition, 1875.

*Manopora gemmulata*, Dana, Zoophytes, 1848, p. 491.

*Montipora ? gemmulata*, Milne-Edwards and Haime, Ann. d. Sci. Naturelles, 3<sup>e</sup> Zool., xvi. (1857) p. 62; and Les Coralliaires, iii. (1860) p. 214.

*Description*.—Corallum contorted and foliaceous. Folia in gracefully clustering clumps, 6 inches high, 2–3.75 mm. thick. Outer surface smooth, not wrinkled.

Calicles regular, scattered, "short subtubiform." Aperture slightly elliptical, 1.25 mm. long, neatly 12-rayed. "The centre of the bottom (? columella) a short thin line."

Dana considered this species as a transition between *Manopora* and *Turbinaria*; it is claimed as a true Turbinarian by Verrill in the Appendix to Dana's 'Corals and Coral Islands.' Habitat not recorded.

The only recorded specimen belongs to the Academy of Natural Sciences of Philadelphia.

## Group V.—TURBINARIÆ MESETERIFORMES.

*Those Turbinarians in which the edge of the cup curls up at more or less regular intervals to form open cylinders, or finger-shaped processes. The intervening tracts of the margin grow out as more or less horizontal lobes, which again curl up to form new cylinders.*

Species 37. *Turbinaria mesenterina*. (Pl. XV.; Pl. XXXII. fig. 10.)

*Explanaria mesenterina*, Lamarck, Anim. s. Vert., ii. (1816) p. 255.

? *Gemmipora mesenterina*, Blainville, Manuel, 1834, p. 387.

*Explanaria cinerascens*, Ehrenberg, Korallenthiere des rothen Meeres, 1834, p. 82; cf. Klunzinger.

Non *Turbinaria mesenterina*, Milne-Edwards, Les Coralliaires, 1860, p. 166.

*Turbinaria mesenterina*, Klunzinger, Korallenthiere des rothen Meeres, ii. (1879) p. 50, pl. vi.

*Description*.—Corallum a flat nodulated mass built up by an extending fringe of fronds, which curve upwards and roll round to form short, thick cylinders; margin of frond thick, pierced by a conspicuous row of deep round holes, representing young calicles.

Calicles tend to project on hemispherical eminences. Apertures circular, parallel with the surface of the cœnenchyma, 2 mm. in diameter. Septa 18 to 20 (22 to 24, Klunzinger), very inconspicuous; where a ridge-and-furrow system is developed, the former run over the margin of the calicle to descend vertically as thin ridges or septa round the large, deep (1 to 1.5 mm.), cylindrical fossa. The interseptal loculi not sharply marked off peripherally. The columella is nearly flat and loosely spongy.

The cœnenchyma appears granular, but is finely echinulate, with a well-developed but delicate ridge-and-furrow system.



Lamarck's specific name was originally applied by him to a single specimen from the Indian Ocean which he identified with *Madrepora cinerascens* of Ellis and Solander. Hence, for a long time the names *mesenterina* and *cinerascens* were used as synonymous, although the name *cinerascens* clearly had the priority. Milne-Edwards was the first who revived Lamarck's name and description for a type distinct from *cinerascens*, and beautifully illustrated in the atlas to his 'Coralliaires.' And still more recently Klunzinger has applied the name to a coral which differs again considerably from Milne-Edwards' *mesenterina*. Further, Dr. Klunzinger identified his *mesenterina* with Ehrenberg's *Explanaria cinerascens*. We have, then, Lamarck claiming that his specimen is the same as Ellis and Solander's *cinerascens*; while Milne-Edwards and Klunzinger affirm it to be distinct, but do not agree as to the Turbinarian to which the name should be applied.

Lastly, Brüggemann in working over the Collection, identified a specimen from the Indian Ocean (Island of Rodriguez) in the National Collection as Lamarck's *mesenterina*. This specimen appears to correspond fairly well with Klunzinger's identification, differing chiefly in the number of septa. Again, the general aspect of the projecting calicles agrees with that shown in Milne-Edwards' figure. But here again there are differences in important details: for instance, the latter author figures the calicles as very sharply circumscribed; whereas in Brüggemann's specimen the margin is jagged, the ridges being continuous with the septa.

Dr. Klunzinger's photograph shows a small portion of the edge of the corallum which appears to resemble, both in the thickness of the corallum and in the characters of the young calicles, the Museum specimen; and further, in both, the calicles are very irregularly distributed.

Lamarck's description of the calicles is very short: "Les étoiles sont creuses, à lames très étroites et nombreuses." Milne-Edwards, instead of "creuses" has "très profondes"; while Klunzinger described those in his specimens as "seicht (1 to 1.5 mm. tief)." In the Museum specimen, they are also about the same depth (1 to 1.5 mm.), but certainly look deep. Lamarck's description of the septa agrees well with that of Klunzinger's species and with the Museum specimen identified by Brüggemann.

Dr. Klunzinger's description of the method of growth seems to accord well with what I have named mesenteriform.

I am therefore inclined, in the main, to accept Klunzinger's description, slightly modified by comparison with the Museum specimen, while I propose to refer Milne-Edwards' specimen to another species, *T. elegans*.

Lastly, Dr. Klunzinger had access to Ehrenberg's types, and we gather from his synonymy, that his *mesenterina* is the same as Ehrenberg's *Explanaria cinerascens*.

There is only one specimen. A fragment from the Great Barrier Reef may, perhaps, belong here on account of its general structural resemblance.

- a. Island of Rodriguez.
- ? b. Great Barrier Reef.

Royal Society.  
Saville-Kent Coll.

#### Species 38. *Turbinaria conica*.

*Turbinaria conica*, Klunzinger, Korallenthier des rothen Meeres, ii. (1879) p. 51.

*Description*.—Corallum usually small, encrusting; margin free, much folded and often somewhat turned up, not so rolled into columns as in the last type.

Calicles very prominent, conical, 4 to 6 mm. broad at the base, 4 to 5 mm. high. Apertures 2 mm. Septa 20 to 21. Fossa deep, 2-2.5 mm. from the aperture to the columella. Cœnenchyma like that of the foregoing.

The chief differences between this and the last species seem to be in the greater projection of the calicles and greater depth of the fossæ. I hardly think these differences alone sufficient, as variations in this respect within the same species, even on one and the same stock, are enormous. There may, however, be other differences in the characters of the calicles, (e. g. in the form of the septa) not given in Dr. Klunzinger's description.\*

There is one fragmentary specimen in the National Collection, from the Red Sea, showing the mesenteriform manner of growth, which may perhaps be *Turbinaria conica*, but in addition to greater prominence of the calicles than in *T. mesenterina*, it has somewhat more conspicuous septa. They do not reach to the half-radius circle, but slope down almost immediately in a gentle curve to the columella. The fossa is open, cylindrical and deep, but hardly 2.5 mm., and the columella is large, rather flat and compact.

The specimen is unfortunately only a fragment, crowded with young, actively growing calicles, with only from 12 to 16 septa and rather loose spongy edges, and not yet in their mature condition. Under these circumstances, it is impossible to make a new name. The great prominence of the calicles, some of the more mature of which have 20 septa, and the general resemblance in manner of growth suggest that the specimen may be provisionally associated with Dr. Klunzinger's Red Sea species *T. conica*. If this is the case, it is not (as Klunzinger suggests) the same as Milne-Edwards' *T. mesenterina*.

*a.* Red Sea.

Purchased.

Species 39. *Turbinaria lichenoides*. (Pl. XVI.; Pl. XXXII. fig. 11.)

*Description*.—Corallum, a flat, nodulated mass surrounded by fringes of small nearly horizontal fronds. The single fronds are 3 to 4 cm. deep and closely packed, much folded and twisted, bent slightly outwards or downwards along their edges. Looked at from below, those composing the outermost ring are seen to be lobed, while many have their edges twisted round underneath, as if rolling up to form a finger or knob or cylinder. The growing margin is thin and almost composed of young calicles with inconspicuous fossæ.

Calicles crowded, but very slightly projecting. Apertures irregular or round or elliptical, the largest and most projecting 3 mm. long diameter. Septa (16 to 24, according to size of calicle) very unequal, long at the sides and short at the ends of the oval apertures. Seen from above, they appear to cross the half-radius circle, but in reality bend round not far from the margin to slope down to form a funnel-shaped, often slit-like fossa. Columella indistinct, sometimes seen as a row of irregular granules.

Cœnenchyma on the upper side finely granular, on the under side velvety.

*a.* Great Barrier Reef.

Saville-Kent Coll. (Type.)

\* Dr. Klunzinger's photograph, pl. vi. fig. 11*a*, which apparently refers to *T. conica* (fig. 15 in the text at the bottom), does not show any great differences in the calicles beyond those described in the text, but the photographs are small, and the finer details would not be easily reproduced.



A single lobate frond, evidently fractured from a large mass, but too small to found a new species, may be placed here provisionally. The calicles closely resemble those above described, the interseptal loculi are, however, sharply bounded peripherally and the growing margin is thicker, while the lobe itself is almost flat, showing no signs of curving round outwards to form a cylinder.

b. Townsville, Great Barrier Reef.

Saville-Kent Coll.

Species 40. *Turbinaria reptans*. (Pl. XVI.; Pl. XXXII. fig. 12.)

*Description*.—Corallum a flat, nodulated mass surrounded by an irregular fringe of short protuberances or cylinders, and round the outermost edge by lobed fronds bending downwards on all sides towards the substratum and rolling up to form cylinders. The single fronds are small and shallow (2 to 3 cm.) and much lobed, and show here and there a marked tendency to bend downwards at their outermost margins. The growing margins are thick; the young calicles appear as small irregular holes.

Calicles crowded, here and there irregularly projecting, three or four rising together to form a nodule. Apertures round-oval, minute, 1 mm. (the very largest reaching 2 mm.). Septa 15 (20 or more in larger calicles) reaching to the half-radius circle, bending round to descend vertically to form the deep, regularly elliptical fossa. Columella not apparent. The interseptal loculi pronounced, but bound irregularly round the margin by the granular cœnenchyma.

The cœnenchyma finely granular.

The single whole specimen which, with a fragment, is all the Collection possesses, is a small complete stock. In its general method of growth it somewhat resembles the last species, but there is no possibility of uniting them. The differences are very pronounced.

a. Torres Straits (West).

Prof. A. C. Haddon. (Type.)

b. Locality not recorded.

[Register No. 93. 7. 1. 8.]

Species 41. *Turbinaria brueggemanni*. (Pl. XV.; Pl. XXXII. fig. 13.)

*Description*.—Expanded cup on short, very thick stalk: margin much folded, the folds generally forming cylinders or bifrontal fusions; margin thick and wavy.

Calicles sparse, project only with their thick margins, elliptical, regular, 2 mm. long diameter. Septa 20 to 22, project to about the half-radius circle; thin, delicate, but with lateral projections, thus continuing the finely spongy character of the cœnenchyma: bend gently over to descend perpendicularly round the neat, rather deep, elliptical fossa. Columella distinct, protuberant, loosely granular. Interseptal loculi distinct, not bounded peripherally.

Cœnenchyma above, spongy, porous, flaky; beneath, stony furrows much arched over, as if the corallum were burrowed through and through just below the surface.

This specimen possesses characters which distinguish it from other known *Turbinarians*. It is especially interesting as it shows the transition between the cup and the adult mesenteriform type of growth. It has the appearance common to all other specimens from Formosa, but the characters of its calicles compel us to separate it from them.

a. Formosa.

Swinhoe Coll. (Type.)

## Group VI.—TURBINARIÆ TABULATÆ.

*Turbinariæ in which the coralla form thick, more or less horizontal, dish-like growths with the margins turned up. Successive growths form flat tiers one above another.*

Species 42. *Turbinaria reniformis*. (Pl. XVII. ; Pl. XXXII. fig. 14.)

*Description*.—Corallum a flat expanse, symmetrically reniform in outline, with margin gently curved upwards; outer margin slightly wavy, inner slightly notched or lobed.

Calicles on hemispherical protuberances, apertures circular (2 mm. in diameter), numerous without excessive crowding, septa 16 to 18, mere granular projections from the margin, but descend as thin ridges vertically round a large cylindrical fossa ca. 1.5 mm. deep. Columella flat, conspicuous, more coarsely granular than lamellate. Interseptal loculi mere notches in the rough granular margin of the calicle.

The coenenchyma granular, round the edges like rusty iron, changing on the under surface to a coarse, and on the upper to a fine echinulation. On the under surface developing marked furrows.

The type specimen is clearly an old stock expanded upon the remains of former stocks. Two former growths can be made out. The lowest and thickest, though dead and decayed, apparently forming the attachment of the stock to the side of some object.

The name of the type refers merely to the accidental form of the outline of the specimen.

From the method of growth, it is obvious that the corallum must be very massive, it only thins at the growing edge. The actual growing edge is a thin, continuous line of young calicles, forming a ridge below the level of the upper surface of the coenenchyma, but in a line with that of the lower: this row will eventually bend upwards and a new row will commence below them. The lines of concentrically arranged calicles thus produced soon become irregular and wavy or zigzag, but are nevertheless recognisable.

There is only one specimen, forming an almost regular kidney- or bean-shaped dish, nearly 40 cm. in longest diameter and 20 across. The dead under surface and former growths are infested by a sponge, closely imitating the coral in the size and appearance of the oscula and in general surface texture and aspect. They might easily be mistaken for portions of the coral which is, as is well known, richly provided with stinging batteries.

a. Palm Islands, Great Barrier Reef.

Saville-Kent Coll. (Type.)

Species 43. *Turbinaria foliosa*. (Pl. XVIII. ; Pl. XXXII. fig. 15.)

*Description*.—Corallum a horizontal fan-shaped plate showing radial ridges and protuberances. The new growth spreads horizontally over the old. Margin thin, turned neither up nor down.

Calicles very protuberant, tall thin cones, the tops of which are quite filled up by the apertures. Apertures minute, round (1.25 mm.), margin very thin. Septa (12) thin, regular.



project far beyond the half-radius circle; bend sharply, and descend perpendicularly round the small circular or oval fossa. Columella a thin flattened plate or vertical rod rising sometimes nearly as high as the margin. Interseptal loculi long, regular, petaloid, being sharply defined peripherally.

Cœnenchyma above, porous, spongy; below, a system of ridges and furrows, the former more or less broken up into short crooked lengths or into points.

The specific name of this coral I found suggested by the late Mr. George Brook in some pencil notes upon the genus. It is apparently not far removed from *T. danæ* (p. 26).

Unlike many of the tabulate growths, which have a very thick, usually dense corallum, the large specimen of *T. foliosa*, though 25 cm. radius and largely unsupported, is not of any very great thickness. It is, further, of comparatively loose texture. It is apparently strengthened by the fan-like arrangements of its foldings.

A smaller specimen, appearing to belong to the type, seems to be in the second period of growth. Points of new growth are found along the margin of the old, as small flat discs (1 to 1.5 cm. in diameter) sitting horizontally on the upturned edges. This looks like a true case of periodic growth, which seems more suitable to the tabulate method of stock formation than the usual regular progressive dying away of the older portions, while the distal portions extend indefinitely.

- |   |                                       |
|---|---------------------------------------|
| a. Locality not recorded.               | [Register No. 37. 5. 13. 63.] (Type.) |
| b. Locality not recorded.               | [Register No. 37. 6. 10. 297.]        |
| c. (A fragment.) Locality not recorded. | [Register No. 43. 3. 6. 113.]         |

Species 44. *Turbinaria rugosa*. (Pl. XIX.; Pl. XXXII. fig. 16.)

*Description*.—A horizontal oval dish, surface much crumpled, and edges much folded; margin thick, 4 to 5 mm.; growing calicles along margin not conspicuous.

Calicles crowded, on conical protuberances, projections often fuse together. Aperture hardly filling the top, oval, often as if the cone head had been pinched; ca. 2 mm. long diameter. Septa (15 to 18) reaching to, occasionally crossing, the half-radius circle; seen from above, thick and granular, often wedge-shaped, bending slowly round from the margin to descend perpendicularly round a small oval fossa. Columella minute, distinct, protuberant, sometimes a thin plate. Interseptal loculi, owing to the granulation of the septa, long thin slits, approaching to long petaloid.

Cœnenchyma above, very finely spongy or granular, under surface appears smooth and stony to the naked eye, but the glass reveals a very fine ridge-and-furrow system.

There is only one specimen and a fragment from Formosa, having a close general resemblance to other species from the same locality. It cannot, however, be classed with any of them. In some respects it approaches nearest to *T. foliosa*.

- |                           |                       |
|---------------------------|-----------------------|
| a. Formosa.               | Swinhoe Coll. (Type.) |
| b. (A fragment.) Formosa. | Swinhoe Coll.         |

Species 45. *Turbinaria crassa*. (Pl. XXXII. fig. 17.)

*Description*.—Corallum a thick, horizontal expanse with gradually curved-up margin, the latter wavy and notched.

Calicles not projecting, scattered, round or elliptical apertures (2 mm.). Septa (18 to 20), not reaching the half-radius circle, sharply differentiated as thin lamellæ from the granular gyrating and interrupted ridges of the cœnenchyma, into which they are continued; bending down immediately to descend vertically round a large, shallow, elliptical fossa. Columella conspicuous, protuberant, spongy. Interseptal loculi open, wedge-shaped, almost square, not sharply marked off from the furrows of the cœnenchyma.

On the upper surface, the cœnenchyma is marked by deep, finely gyrating furrows, separated by irregularly granular ridges of about the same width as the furrows. On the under surface, the ridge-and-furrow system is a little coarser; the furrows, though gyrating, tend mostly to run in the line of growth, the ridges getting thicker and the furrows finer, until, near the margin of the living growth, the latter are merely threadlike, meandering channels in the stony surface of the corallum.

There is, unfortunately, only one fragment of this type, but it is sufficient to reveal the character of the stock. The margin is thicker than in the last species, and becomes very rapidly of great thickness, viz. 1 cm. at a distance of 6 cm. from the margin, 1.75 cm. at 9 cm. from the margin. This very rapid growth in thickness is to be connected with the immersion of the calicles. The broken sections show that the great increase in thickness is above the layer of intercommunication between the polyp-cavities; the turned-up ends of these cavities have accordingly to grow to a great length. This process obviously leads on to the glomerate type of growth.

A small tubercular upheaval of the cœnenchyma on the upper surface corresponds with a headland in the line separating the living from the dead cœnenchyma on the lower side.

a. Great Barrier Reef.

Saville-Kent Coll. (Type)

Species 46. *Turbinaria elegans*. (Pl. XX.; Pl. XXXII. fig. 18.)

? *Turbinaria mesenterina*, Milne-Edwards, Les Coralliaires, iii. (1860) p. 166, pl. E 1, figs. 1a, 1b.

*Description*.—Corallum horizontal, dish-shaped, developed on a previous dish-shaped growth. Margin bent and folded, and surface bulged up irregularly. Margin thick.

Calicles open on thick conical protuberances, the bases of which are generally in contact, so that the cœnenchyma between the calicles appears like a network of narrow valleys. Apertures round or round-oval, of nearly uniform size (2 mm. diameter). Septa about 24, not reaching to the half-radius circle, bending round a deep oval fossa. Columella protuberant, oval, and loosely spongy. The interseptal loculi thick, wedge-shaped or short petaloid, more or less sharply bounded peripherally.

The ridges of the cœnenchyma are short, thin, erect plates, twisted into all shapes, and



jagged at the edges. Between these plates, in the bases of the furrows, the open pores are clearly visible. When the jagged points of the ridges all stand outwards as around the calicles, they appear to be very markedly echinulate.

The coral agrees, in the *character* of the calicles, very closely with the figure given by Milne-Edwards of *Turbinaria mesenterina*, but differs in the sizes of the calicles and in the thickness of their margins. They may perhaps be specifically identical.

Milne-Edwards' description of the corallum, "en général foliacé, contourné, irrégulièrement bossue en dessus, quelquefois encroûtant," might or might not apply to the tabulate method of growth.

Dr. Klunzinger suggested that Milne-Edwards' *Turbinaria mesenterina* was the same as his *T. conica* (see above, p. 58). Both are from the Red Sea.

The type specimen, together with a younger, more conical growth, is from Tongatabu, and agrees closely in general aspect with *T. pulcherrima* and *T. veluta* from the same locality. On this striking resemblance of specimens from the same locality, see p. 18.

There are, further, two other nodulated fragments from the Great Barrier Reef, which, from the characters of the calicles, appear to belong here. If so, they have lost the character of the cœnenchyma peculiar to Tonga Turbinarians, and the calicles are slightly smaller.

<i>a.</i> Tongatabu.	J. J. Lister, Esq. [91. 3. 6. 21.] (Type.)
<i>b.</i> Tongatabu.	J. J. Lister, Esq.
<i>c.</i> Rocky Island, Great Barrier Reef.	Saville-Kent Coll.
<i>d.</i> Great Barrier Reef.	Saville-Kent Coll.

Species 47. *Turbinaria veluta*. (Pl. XX.; Pl. XXXII. fig. 19.)

*Description*.—Corallum a horizontal growth, somewhat bent, arching over former horizontal growths, and attached to the upturned edges of the latter, leaving hollow chambers between. Margin and corallum not specially thickened.

Calicles very protuberant (to 4 mm.), on thick blunt cones (almost cylinders), the tops of which are filled by the round-oval apertures (2.5 to 2 mm. long diameter). Septa (about twenty-four) very irregular, seen from above, project beyond half-radius circle; in reality they slope gradually down to the columella, then descend sharply all round it without appearing in contact with it. The shallow fossa is thus funnel-shaped, and the columella, a small sharply demarcated protuberant oval mass of loose spongy texture. The interseptal loculi are not sharply marked off from the surrounding cœnenchyma.

The cœnenchyma is quite smooth to the touch, and looks like a beautiful velvet; under the glass it is seen to consist of an exquisitely delicate arrangement of gyrating ridges and furrows, the former being very finely echinulate.

There is only one specimen from Tongatabu, showing the same general appearance as the other specimens from the same locality, but differing too greatly in the characters of the calicles to be classed with them. There is no other specimen in the Collection at all resembling this.

<i>a.</i> Tongatabu.	J. J. Lister Esq. (Type.)
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Species 48. *Turbinaria marmorea*.

Rehberg, Abh. Naturwiss. Hamburg, xii. (1892) p. 43, pl. iii. figs. 2 and 3.

*Description*.—Corallum composed of very large, broad, and flat or folded leaves, which are very thick, 2 cm., but suddenly get thin at the margin.

Calices oval and small, 5 to 10 mm. from one another, immersed or hardly projecting. Septa (average 16); columella distinctly long; the septa slightly dentate; interseptal loculi pronounced petaloid.

Coenenchyma sharply bounded peripherally, solid and marble-like, fissured, and round the calices as if regularly burrowed through by worms; the under side is spongy but compact.

Two specimens of this coral, one from the Palau Islands and one from Ponapé, are described by Rehberg under the above specific name. He states that they had been originally provisionally placed by Brüggemann under *T. cinerascens*, Esper. Rehberg's specimens, to judge from the aspect of two calices and the surface of the surrounding coenenchyma, as figured by him, appear sufficiently distinct. Unfortunately, there are no specimens in the National Collection.

Judging from Rehberg's figure (pl. iii. figs. 2 and 3), which shows the great thickness of the coenenchyma below the layer of intercommunication of the polyp-cavities, coupled with his description of the rapid thinning of the corallum near the margin, I conclude that this was a horizontally growing form apparently belonging to the tabulate group. On the other hand, Rehberg speaks of a leaf 35 cm. "high," appearing to assume that its original position was upright, and he further compares it to Dana's *T. brassica*. For these reasons, I at first thought it belonged to the foliate group.

From the size of the single fronds, Rehberg concludes that a stock might be several metres in circumference. The type is in the Hamburg Museum of Natural History.

## Group VII.—TURBINARIÆ GLOMERATÆ.

*Turbinarians in which the growth in thickness which characterises the last group is so great that they form spherical or hemispherical masses, the margins hanging down and creeping round former growths.*

Species 49. *Turbinaria stellulata*\* (Pl. XX.)

*Astrea stellulata*, Lamarck, Anim. sans Vert., ii. (1816) p. 261.

*Astreopora stellulata*, Blainville, Manuel d'Actinol. (1834), p. 383, pl. lx. figs. 4 and 4a.

*Astreopora stellulata*, Dana, Zoophytes (1848), p. 416.

*Turbinaria stellulata*, Quelch, † Chal. Rep., xvi. (1886) p. 168.

\* Rehberg (Abh. Naturwiss. Ver. Hamb., xii. (1892) p. 44) has suggested the name *T. hemisphærica* as a substitute for *T. stellulata*. This name might well be applied to some of the more perfectly hemispherical forms now grouped under the general heading *stellulata*. The term would not apply to all the forms assumed by Glomerate Turbinarians (cf. Pl. XX.).

† Milne-Edwards was the first ('Les Coralliaires,' p. 167) to suggest that the *Astreopora stellulata* of Blainville might be a true Turbinarian. This suggestion was adopted by Quelch in his 'Challenger' Report on the Reef Corals.

*Description.*—Corallum a solid mass, the thick margin growing downwards, seldom turning outwards as a distinct ridge.

Calicles, with margins only protruding, or else quite immersed; apertures irregularly round, diameter 2·5 mm. and under. Septa (24 to 30) very unequal, not reaching the half-radius circle, but sloping down from the margin to form a deep, almost cylindrical, or shallower funnel-shaped, fossa. Columella protuberant, irregularly round or oval, rather compactly foliate, not visibly in contact with the septa. Interseptal loculi narrow, in some specimens sharply marked off from the cœnenchyma.

Cœnenchyma, as a rule, finely reticulate but showing great variations.

There are eight specimens of massive Turbinarians in the Collection, excluding the almost hemispherical masses of *T. peltata*.

I was at first disposed to look upon these as merely massive varieties of other types. Two of the specimens appear to be closely allied to *T. elegans*, a third to *T. irregularis*. But on the other hand, the glomerate type of growth appears to be a normal and specifically distinct development. If any classificatory value is to be placed on the different types of growth, there is no adequate reason for excluding this one which is as marked as any other.

No two of these specimens are alike, and they could and perhaps should be arranged under eight different headings. I have, however, divided them into two groups under the names *stellulata* and *globularis*, according as the calicles are generally immersed or protuberant. The protuberance of calicles in specimens growing rapidly in thickness seems to me to be an unexpected feature worth emphasising.

I have, therefore, arranged six of the specimens under the old species *stellulata* of Blainville. The remaining two species come under the next heading, *T. globularis*.

A section through a large specimen reveals the typical method of gemmation of the Turbinarians. But the polyp-cavities have to lengthen indefinitely to keep pace with the thickening cœnenchyma. There are traces of transverse septa (tabulæ), as if the animals withdrew from the lower portion of the cavities. Secondary budding of these long polyps is not the rule, although it may occur, as in all Turbinarians. In that case, it is a reversion to a more primitive and less specialised method than that typical of the genus.

The largest specimen \* is interesting as showing the different growths, one piled on the other; the upper ones creeping down on all sides over the lower ones.

The polyps of the Fiji specimens have a yellowish colour.

*a-d.* Tongatabu.

*e.* Fiji Reefs.

*f.* Tizard Bank, China Seas, 5 to 10 fathoms.

J. J. Lister, Esq.

H.M.S. 'Challenger.'

H.M.S. 'Rambler.'

\* Figured in 'Notes Morphological and Systematic, on the Genus Turbinaria,' Ann. and Mag. Nat. Hist., xv. (1895) pl. xix.



Species 50. *Turbinaria palifera*.

*Astrea palifera*, Lamarck, Anim. sans Vert., ii. (1816) p. 262.

*Gemmipora palifera*, Blainville, Manuel d'Actinol. (1834), p. 387.

*Gemmipora palifera*, Dana, Zoophytes (1848), p. 409; Atlas, pl. xxix. figs. 2, 2a, 2b.

*Turbinaria palifera*, Milne-Edwards, Les Coralliaires, iii. (1860) p. 167.

*Description*.—Corallum massive, subglobose, and lobed. Calicles much crowded on cylindrical prominences 2·16 to 6·5 mm. high, 3·25 mm. in diameter, somewhat smaller at the summit; the margin of the aperture is thick and stout. Septa (ca. 30) "even." Fossa 2·5 mm. deep, small, and flat at the bottom.

This is a very remarkable coral and deserves to be closely studied. A glomerate Turbinarian (see Dana's figure, 'Zoophytes,' Atlas, pl. xxix. fig. 2), with tall projecting calicles, nearly all of the same size, appearing all to radiate from a common centre, without any appearance of a growing creeping edge with non-protruding calicles, is very difficult to understand. If a glomerate Turbinarian at all, it is certainly a very aberrant type. Some of the specimens collected were "lobed and subdivided," one was 6 inches across and 4 inches thick. A section through a specimen would be most instructive in showing the line of its departure from the type.

The specimens described by Dana were from Fiji, where *Turbinaria stellulata* with the nearly immersed calicles also occurs, and in both cases, the polyps are described as yellow or yellowish. Until we have further information, we are driven to the conclusion that *T. palifera* is an extreme development of the glomerate type with protuberant calicles as in *T. globularis*. Yet this assumption is far from satisfactory.

There is unfortunately no specimen in the National Collection.

Species 51. *Turbinaria parvistella*.

*Turbinaria parvistella*, Saville-Kent, P.Z.S., 1871, p. 285.

*Description*.—Corallum massive, convex.

Calicles sparse, not protuberant; apertures level with the surface, small, ca. 2·5 mm. Septa 12 to 18, of equal size. Columella spongy.

Coenenchyma "abundant," very porous.

The type specimen of the coral is in the Oxford Museum, and a fragment is said to have been deposited in the National Collection, but there is no record in the Register of its having been presented, and it is not included among the Turbinarians at present in the Collection.

Locality not recorded.

Species 52. *Turbinaria globularis*. (Pl. XX.; Pl. XXXII. fig. 20.)

*Description*.—Corallum an almost globular mass, the growing edges hanging down over and creeping round the dead remains of former growths of the same colony.

Calicles protuberant as thick truncated cones, showing no regularity in size and height, some of the larger and older being 5 mm. in diameter of the circular tops, and 6 mm. high. Calicles show secondary budding from their sides, the smallest buds are mere points on the lateral slopes of the cones or at their bases. The aperture occupies the whole summit of the projection. The septa vary from 10 in the minute buds to 42 in the larger calicles. They are closely arranged, thin, and reach nearly to the half-radius circle. They are very regular in the medium-sized calicles, but irregular in the largest. Slanting down from the margins, they descend suddenly round an oval, cylindrical, or bowl-shaped fossa, which is often deep or else partially filled by a protuberant, often globular, spongy columella.

Interseptal loculi slit-like, petaloid.

Cœnenchyma rather coarsely reticulate, slightly echinulate, with vertical ridge-and-furrow system on the sides of the protuberant calicles.

There are two specimens grouped under this heading, the type being an ovoid mass 20 cm. long by 16 across, from Diego Garcia, and the other a nodule 9 cm. long, from Palm Island, Great Barrier Reef, which differs from the type in having much smaller calicles. The substratum in the larger specimen shows signs of being composed of various earlier growths of the same stock.

There are two interesting characters presented by these specimens: (1) adventitious budding appears to be the rule, and must be regarded as a return to earlier methods, from the more specialised type of budding of the genus. (2) the calicles protrude, whereas in the glomerate growth they are typically immersed by the rapidly thickening cœnenchyma. This is clearly to be taken in connection with the adventitious budding, which would allow a certain number of polyps, as it were, to get the start of the cœnenchyma.

There is unfortunately no good section to show the exact relations of the adventitious budding to the specialised Turbinarian method. The adventitious budding probably only takes place at the very thickest portions. The smaller of the two specimens illustrates the conditions very well. One half of the nodule is of no great thickness and the calicles are of nearly equal size, hardly protuberant and scattered, new calicles appearing along the growing edge; the other half, however, which is thick and solid, is closely beset with large projecting calicles interspersed with minute buds. It looks as if the adventitious budding were a safeguard against complete submergence of the calicles by the cœnenchyma, this being a phenomenon discoverable in other cases of threatened submergence.

It is worth noting that the very possibility of explaining the different features of these corals by the physical conditions of growth, however gratifying it may be in itself, tends at the same time to shake one's confidence in their value as taxonomic characters.

*a.* Diego Garcia.

*b.* Palm Island, Great Barrier Reef.

G. C. Bourne, Esq. (Type.)  
Saville-Kent Coll.

## Group VIII.—TURBINARIÆ BIFRONTALES.

*Turbinarians in which the margin of the cup forms vertical folds, which fuse back to back; the subsequent growth of the stock is carried on by these folds, which thus form fronds with calicles on both sides.*

Species 53. *Turbinaria bifrons*. (Pl. XXI.; Pl. XXXIII. fig. 1.)

*Turbinaria bifrons*, Brüggemann, Ann. and Mag. Nat. Hist., xix. (1877) p. 415.

*Description*.—Corallum “consists of thin, vertical, variously plicate plates,” with calicles on both sides. The live zone narrow, 4–5 cm. The suture along the ridge traceable here and there, but much obscured.

Calicles close but not crowded, arranged “quincuncially (the oblique series being more pronounced), distant by about the length of their diameter.” Lower margin slightly projecting so that the aperture faces upwards and outwards. Apertures oval, often oblong, less than 2 mm. long diameter. Septa 18–20, not thin lamellæ, but thick and granular, seen from above projecting to the half-radius circle, in reality sloping straight inwards from the margin till near the columella, where they dip down vertically round it to form a regular oval fossa at the bottom of the funnel formed by the upper portion of the septa. Columella protuberant, very compact and glassy.

Interseptal loculi narrow jagged slits, not marked off peripherally from the furrows of the cœnenchyma.

Cœnenchyma shows a very beautiful and delicate ridge-and-furrow system, the ridges being surmounted by single or double rows of fine granules, spines or spinous plates, the last named being arranged transversely across the ridges.

Brüggemann described this type from a portion of an old stock, which had lost all traces of the early cup form. Its habitat is unfortunately not known.

Among the many small cup-shaped young in the National Collection of Turbinarians which show traces of the bifrontal folding, is a group from West Australia which seems to form a transition series between this type and the next. Many of the smaller specimens of this group show unmistakable affinities in the characters of the calicles and of the cœnenchyma to the type of this species, while some of the larger specimens appear more like *T. conspicua* in these points; and yet it does not seem possible to divide them. They have many characteristics in common, perhaps the more startling is the very early formation of the bifrontal folds. There are specimens only 7 cm. in diameter which have lost all traces of their cup shape, except the stalk, and are a mass of shallow fronds. It is possible that these are all the young stages of a new type; without, however, the complete series showing the method of growth from the young to the old stock, it is impossible to do more than speculate on this point (Pl. XXI., two small specimens together).

Provisionally, then, I propose to classify these small specimens as early stages of *T. bifrons*, in spite of the resemblance of some of them in certain points to *T. conspicua*. My chief reasons for not including any of these under this latter type are: (1) they appear to



belong to one another, coming all from the same locality (on the other hand, cf. Introduction, p. 18); (2) some of them show unmistakable resemblance to *T. bifrons*; (3) all of them seem to form bifrontal folds early, the folds thus being small and narrow, whereas in *T. conspicua* the cup seems to grow to some size before the edge folds; and the fronds are large and deep.

Many other interpretations of the phenomena presented by this curious little group of specimens are possible, but until we have more and older specimens they must remain, like that above put forward, purely speculative.

Rehberg\* describes, under this specific name, a large stalked, cup-shaped specimen from the Tonga Islands, with broad folds fused back to back, the whole being 40 cm. across and 35 high. This, however, need not belong to this particular type of bifrontal Turbinarian. It may belong to one of the following types. The depth of the living zone in *T. bifrons* is too short to be developed from a cup, which, with its folds, reaches 35 cm. The fronds in the subsequent growth of such a cup would almost certainly be deep, like those of *T. conspicua*.

A fragment of an old stock.

a. Locality unknown.

[Register No. 53. 4. 8. 16.] (Type.)

Group of young specimens from West Australia showing affinities both with *T. bifrons* and with *T. conspicua*.

b-g. West Australia.

Purchased, Capt. Beckett.

A minute specimen (86. 2. 26. 9.) 7 cm. in diameter, and showing an abnormal number of twisted bifrontal folds. A great number of Ophiurids lurk in the crevices (Pl. XXI., the specimen on the right.)

h. West Australia.

Capt. Beckett.

#### Species 54. *Turbinaria conspicua*. (Pl. XXII.; Pl. XXXIII. fig. 2.)

*Description*.—Corallum develops from a cup, the folds of which fuse back to back, the older coralla consisting of erect fronds with calicles on both sides; the living zone on fronds may be very deep, 15 cm. or more.

Calicles never (?) projecting. On erect fronds the lower margin may stand out so that the aperture looks upwards and outwards. Aperture oval, about 2 mm. longest diameter. Septa 24, regular, often thick and granular, especially in young specimens, not reaching to the half-radius circle, bending round from the margin to descend vertically round a large oval, or slantingly round a funnel-shaped, fossa. The columella thus varies from a large, protuberant, oval mass, to a thin line of granules rising up in the slit-like base of the funnel. Transition stages can often be found on one and the same stock.

The interseptal loculi are little more than notches between the thick septa.

The coenenchyma is at the surface rough and granular, in section, usually very dense; without any marked development, at least in the older stocks, of a ridge-and-furrow system.

It is impossible satisfactorily to divide up the many specimens which I have grouped under this head, in spite of the great variations which they show in almost every point.

\* Abhandlungen aus dem Gebiete d. Naturwissensch. Hamburg, xii. (1892) p. 45.

The following variations may be specially noted.

1. Whereas some stocks have but few erect fronds, with great depths of living coral, other stocks are composed of a mass of closely gyrating fronds showing only a very narrow living zone (5 to 6 cm.). In these cases, the narrowness of the living zone is clearly due to the crowding of the fronds; this is shown by its much greater depth wherever, on the same stock, the fronds are more exposed.

2. The suture along the edges of the fronds is very variously developed. A slight ridge separating the young calicles of the one face from those of the other is almost always to be seen. In others, again, this ridge is widened, and here and there shows traces of a median trough. This trough may, again, widen and deepen as if the fused folds were about to separate again.

3. The erect fronds may break up into finger-shaped processes, which give the whole stock an appearance but little resembling that of the type.

4. In addition to these, there are the differences in the calicles mentioned above, the small funnel-shaped fossæ being very frequent on erect fronds when the calicles look upwards, while the calicles with the large oval fossæ and conspicuous columellæ are very frequent in younger cup-shaped specimens.

5. Again, while the granular character of the cœnenchyma is marked on the erect fronds, in the young cups the flow of nutritive matter downwards towards the base and stalk is indicated by a marked ridge-and-furrow system.

Had there been only a few specimens showing the variations above described, they would almost certainly have been classified under so many different specific names.

The question may then be asked, why separate this from *T. bifrons*? The main distinction between the two (which I wish to emphasise by separating them) lies in the great depth of the living frond in the latter, and its narrowness in the former.

The National Collection fortunately possesses a great number of specimens of this magnificent coral, almost all collected by Mr. Saville-Kent in Shark's Bay. They show all stages of growth, from the minute cup but a few cm. across, to gigantic bushes of erect fronds 3 feet high, and many feet round.

These upright fronds show the phenomenon which at first led me to believe in successive periods of growth; the real explanation of the sharp contrasts between the living and dead portions being found in the downward streamings of the cœnenchyma. (See *Intro.*, p. 12.)

The colour of the stocks before bleaching appears to have been dark brown.

Old stocks of large size.

*a-c.* Shark's Bay.

Saville-Kent Coll.

Of these, the specimen registered 94. 3. 9. 4. is specially worthy of note because two varieties, one with large columella and one with small, are growing side by side without fusing. They are in conjunction with *T. magna*. The whole group of three specimens further illustrates the striking likeness so often noted between corals of different species when coming from the same locality.

*f.* Shark's Bay (also with *T. magna*).  
*g-l.* Shark's Bay.  
*m.* Shark's Bay.

Saville-Kent Coll. [Register No. 94. 3. 9. 7.]  
Saville-Kent Coll.  
Saville-Kent Coll.

In this specimen (94. 3. 9. 2.) many of the fronds divide up into flat (or even round) finger-shaped processes.

*n.* Shark's Bay.

Saville-Kent Coll. 94. 3. 9. 23.

Small specimens and fragments.

*o.* Shark's Bay (with *T. magna*).

Saville-Kent Coll. 94. 3. 9. 12.

? *p.* North-East Australia.

H.M.S. 'Alert.' 93. 7. 1. 9.

*q.* ?

? 93. 7. 1. 12 ?

*r.* Shark's Bay (two fronds growing from a dead perforated fragment).

Saville-Kent Coll. 95. 8. 29. 13.

Young specimens (possibly) of *T. conspicua*.

*Turbinaria crater* (partim), Quelch, Chal. Rep. Cor., 1886, p. 166.

*Turbinaria cinerascens*, Quelch, Chal. Rep. Cor., 1886, p. 167.

Young cups ranging from 2 to 6 cm. in diameter, and which have received many different names, *T. crater*, *T. cinerascens*, &c., by previous workers. They are in reality too young to classify, but appear, at least in many instances, to be the early stages of *T. conspicua*. Some of them already show the bifrons type of folding, and further, the type of the calicles appears to connect them with *T. conspicua* (or perhaps with *T. magna*, see above). As above stated, the calicles in these young specimens are remarkable for the large oval fossæ and conspicuous columella; the funnel-shaped fossa of many older stocks may be an adaptation to growth under different conditions, viz. on the sides of erect fronds.

*a.* Locality not recorded.

[Register No. 82. 4. 18. 3.]

*b-d.* Somerset Shore, Cape York.

H.M.S. 'Challenger.'

*e-h.*

*i-m.* Great Barrier Reef.

Saville-Kent Coll.

*n.*

*o.* Thursday Island, Great Barrier Reef.

Saville-Kent Coll.

*p.* Bellona Reef (5 fathoms).

F. M. Rayner, Esq.

Very small specimens showing bifrontal folds.

*q-s.* Great Barrier Reef.

Saville-Kent Coll.

*t.* Port Molle, Queensland (5 fathoms).

H.M.S. 'Alert.'

*u.* Locality not recorded.

#### Species 55. *Turbinaria gracilis*. (Pl. XXIII.; Pl. XXXIII. fig. 3.)

*Description*.—Corallum develops as in *T. conspicua*. The fronds are deep, thin, and straight. They sometimes give rise to secondary fronds, the line of intersection of their planes being in the direction of their growth. The suture along the edge is marked by a median ridge, which may have a triangular depression in the line of intersection of two fronds.



Calicles as in *T. conspicua*, with, however, a greater tendency to develop thick, ring-like margins, projecting somewhat above the surface, so echinulate as to appear furry. Septa (20 to 24) are perhaps thinner and less regular than in *T. conspicua*. The same variations in the shape of the fossa and columella as in *T. conspicua*.

The cœnenchyma shows a very pronounced ridge-and-furrow system, the ridges being highly echinulate and the furrows very deep. As in *T. conspicua*, this is more marked in the younger specimens than in the older, but in all cases, it is more marked than in that type.

This coral may be only a local variety of *T. conspicua*. In the unbleached state, it was of a blue-grey colour, whereas *T. conspicua* is brown. The very pronounced ridge-and-furrow system gives it a peculiar appearance. It changes colour according to the direction in which it is looked at; if seen direct, the dark furrows are most conspicuous, if sideways, the whitish echinulations of the ridges are alone visible.

There are five specimens forming a beautiful series illustrating the development of the stock from the early cup form.

<i>a-d.</i> Gulf of Carpentaria.	Saville-Kent Coll.
<i>e.</i> Great Barrier Reef.	Saville-Kent Coll.
<i>(?) f.</i> Great Barrier Reef.	Saville-Kent Coll. [Register No. 92. 12. 1. 645.]

Species 56. *Turbinaria dendrophyllia*. (Pl. XXI.; Pl. XXXIII. fig. 4.)

*Description*.—Corallum nearly even cup-shaped externally. Internally, infoldings of the edge form vertical ridges which are wavy and divide up. A suture may or may not be visible along the top of the ridge; margin thick and crumpled. Stalk rather long, and graceful.

Calicles not typically protuberant, but when projecting tend to put out adventitious buds at the margin or to divide, giving rise to short projections or branches, consisting of bundles of calicles. Calicles very unevenly distributed, varying also greatly in size, round-oval (ca. 2 mm.). Ca. 20 septa, almost reaching the half-radius circle, with a tendency at one or more points round the calicle to meet, to form structures resembling the dendriform septal arrangement of the genus *Dendrophyllia*. The septa slope to descend perpendicularly round the rather deep fossa, in the bottom of which is a light inconspicuous columella which is clearly seen to be a product of the septa. The interseptal loculi are irregularly petaloid, but are not sharply circumscribed.

The cœnenchyma is stony, the furrows being mostly shallow, while the ridges are broad and bluntly toothed or granular along their crests, or else like scattered worm burrowings.

The type specimen is a rather deep cup 20 cm. in diameter and 12 high. Externally the cup form is retained, i. e. it shows but very slight indications of the internal foldings. The sutures along the tops of the ridges may even gape.

There is one other specimen from the same district (Roebuck Bay, West Australia), with respect to which it is difficult to decide whether the resemblances are due to specific identity or to local conditions. The differences are very marked, but until we know more of

the laws of growth of these colonial Coelenterates, it is not possible to say whether the differences or the resemblances are of the greater taxonomic importance. Having selected the growth form as of chief value, we are compelled to class these two specimens provisionally together. The resemblances are the following: the cup shape is retained nearly symmetrically externally, while internally, bifrontal foldings, wavy and tending to branch, run in towards the axis of the cup; the protuberant calicles tend to bud adventitiously, giving rise to thin, finger-shaped processes. The stalk is comparatively thin and graceful. The calicles agree fairly well in size, distribution, degree and manner of protuberance, in the number of septa, and in the light character of the columella. The differences, however, are not unimportant. The corallites have shorter and thicker septa; there is a light but conspicuous columella. The meeting of the septa, or character on which the species is founded, is almost confined to the younger calicles at and within the edge and in the submerged calicles in the bottom of the cup. The coenenchyma is coarser and the cup more open and shallow. There is no suture along the tops of the infoldings.

*a.* Roebuck Bay, West Australia.

Saville-Kent Coll. (Type.)

*b.* Roebuck Bay, West Australia.

Saville-Kent Coll.

#### Group IX.—TURBINARIÆ VARIE CONTORTÆ.

Species 57. *Turbinaria contorta*. (Pl. XXIV.; Pl. XXXIII. fig. 5.)

*Description.*—Corallum is a cup, one edge of which has been pulled down so that the calicles face outwards. This displaced portion of the cup wall grows right and left symmetrically round the cup on its outside. The two growths meet and fuse at a point diametrically opposite to that of the original folding. On meeting, they again bend round as if to grow back again. This origin is partially disguised by further growth of the margin.

Calicles crowded, projecting as short, thick cones. The aperture oval (2.5 mm. long, 1.5 mm. short, diameter and under). Septa (16) granular, projecting far beyond the half-radius circle, bending gradually round from the margin to descend vertically round a narrow, long-oval fossa. Columella a thin granular plate, sometimes broken into three or four points, rises to the top of the fossa. Interseptal loculi long wedge-shaped, owing to the granulation of the septa so indistinct that the slit-like median fossa appears at first sight to be the aperture of the calicle. Irregularly bounded peripherally by a light, spongy, finely echinulate coenenchyma.

The fine echinulations and granulations of the coenenchyma give the corallum a silky appearance. On the under surface the ridge-and-furrow system is fine but distinct.

There is only one specimen of this Turbinarian. It is impossible to say, until more specimens are discovered, whether its remarkable growth is normal or accidental. A diagram illustrating the method of folding, together with the figure of the whole stock, which was given in the 'Annals and Magazine,' 1895, will explain the growth.

There is only one other Turbinarian in the Collection showing any trace of this method of growth. The large specimens of *T. mollis* (91. 8. 9. 8. Registered No.) has one edge of the cup folded down, the fold growing out to right and left on the outside of the cup (see Pl. V.).

In the above description I have assumed that the central conical cavity is the original cup. This assumption is quite warrantable, and, indeed, almost necessitated by the present state of our knowledge of the development of the Turbinarian stocks. The only doubt which rises in my mind as to whether this is actually the original cup or a secondary cup formed by a fold of an earlier stock, is due to the complete disguising of the stalk. This, however, is hardly to be wondered at. When the process began, the stalk would be comparatively thin. The necessary thickening which would accompany such luxuriant growth, would adapt itself to the needs of that growth, and the primitive stalk would, it seems to me, soon be completely lost.

*α. South Chinese Seas.* { Commissioners, Chinese Court, International } (Type.)  
Fisheries Exhibition of 1883.

Species 58. *Turbinaria subversa*. (Pl. XXV.; Pl. XXXIII. fig. 6.)

*Description.*—Corallum a nodulated mass, with thin margin much contorted, drooping round the stalk, which has completely enveloped a loose mass of extraneous matter. The stock is thus free, but weighted by the fragment of the substratum enclosed in its stalk.

Calicles sparse, short, thick protuberances, often only the thick margins project. Aperture smaller than the top of the protuberance, oval, regular, 2.5 mm. long diameter. Septa thick, very variable (15 to 28), not equal, projecting to or beyond the half-radius circle, bending round rather sharply to descend perpendicularly round a distinct oval fossa of medium depth. Columella distinct, oval or straight, coarsely granular, protuberant. Interseptal loculi according to the number of septa developed, distinct, or very thin and slit-like, not bounded peripherally but continuous with the furrows of the cœnenchyma.

Coenenchyma finely echinulate, with a furry appearance.

It is impossible to say whether this is an abnormal or a normal specimen. The young cup was apparently attached to some loose fragment of the substratum, and in course of time rolled over on its side. The stalk grew round the mass, which thus acted as an anchor. This appears to be purely accidental. Yet it may have become normal to a species flourishing in a locality where the substratum largely consists of loose fragments. The characters of the calicles are peculiar, and until we possess fixed stocks showing the same calicles, we must regard this specimen provisionally as representative of a type. On the other hand, again, it must not be forgotten that the change in position due to rolling over, might seriously modify the general characters of the calicles. But as we have no light to guide us in estimating the influence of such change of position, we must be content with provisionally labelling the specimen as representing a new type.

a. Palm Island, Great Barrier Reef.

Saville-Kent Coll. (Type.)





## ASTRÆOPORA.

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### INTRODUCTORY.

THE small genus *Astræopora* calls for little introductory comment. It very naturally follows the two genera *Madrepora* and *Turbinaria*, already catalogued, as the three form a well-demarcated group of coenenchymatous corals, i.e. of corals out of the development of which one of the two elements of the typical coral skeleton has practically dropped. In all these the epitheca appears in the earliest stages alone, persisting only in certain explanate forms, while the great mass of the coral substance is built up entirely by the septa and their synapticular connections, forming together the coenenchyma. The genus *Astræopora* may, perhaps, be described as consisting typically of glomerate coenenchymatous corals, in contrast on the one hand with *Madrepora*, consisting typically of branched, and on the other with *Turbinaria*, consisting typically of foliate coenenchymatous corals.

The three do not lend themselves to any trustworthy phylogenetic arrangement. It is safest to deduce them independently from some more primitive coenenchymatous coral, which is now, perhaps, only represented in the earliest encrusting stages of *Astræopora* and *Madrepora*.

The relation between these three corals and *Montipora* and *Porites*, which are also coenenchymatous corals in which the epitheca plays an equally subordinate part, will be discussed in the next volume.

### HISTORICAL.

The genus *Astræopora* was founded by de Blainville,\* in 1830, to contain certain specimens which he separated from Lamarck's genus *Astræa*. In the work above quoted, he selected seven of Lamarck's *Astræa*, viz. *A. myriophthalma*, *A. stellulata*, *A. pulvinaria*, *A. retiformis*, *A. obliqua*, *A. palifera*, and *A. punctifera*.† Further study of Lamarck's specimens, however, induced him, in 1834,‡ to replace *A. retiformis* among the *Astræa*, to omit *A. obliqua*,§ and to place *A. palifera* in the genus *Gemmipora* (*Turbinaria*).

\* Dictionnaire des Sciences Naturelles, lx. p. 348.

† Cf. Lamarck's Animaux sans vertèbres, ii. (1816) p. 260.

‡ Manuel d'Actinologie, p. 383.

§ I have so far not succeeded in ascertaining the fate of this species.

The number of species was now reduced to four, while the rearrangement led de Blainville to the conclusion that *Astræopora* was closely allied to *Gemmipora* (*Turbinaria*).

The new genus was thus removed far from *Astræa*, and placed among the Madreporæ, but its assumed affinity with *Gemmipora* was not marked by any rearrangement in the order of the genera originally given in the 'Dictionnaire des Sciences Naturelles.'

The conclusion thus arrived at by de Blainville, that *Astræopora* might, "without inconvenience," be united with *Gemmipora* (*Turbinaria*), was adopted with a note of interrogation by Dana in his 'Zoophytes of the United States Exploring Expedition,' in 1848. The note of interrogation is easily explained when Dana's method of classification is taken into account. The *Gemmiporidae* were the third family of his second tribe *Caryophyllaceæ*, which were distinguished from the two other tribes *Astræaceæ* and *Madreporaceæ* by inferior budding. While the budding of *Turbinaria* does at first sight seem to be inferior,\* there is no such appearance in *Astræopora*. Hence Dana, while accepting Blainville's conclusion that the two genera were closely related, was compelled to doubt its correctness according to his own principles of classification. The chief distinction which Dana draws between *Astræopora* and *Gemmipora* is, that the former has the calicles "obsolete or nearly so," while the latter has "the calicles prominent, cylindrical or conico-cylindrical." As a matter of fact, no such distinction exists, both obsolete and prominent calicles occurring in both genera. Dana also accepted four species which differ from the four adopted by Blainville. He followed Lamarck's suggestion that *A. pulvinaria* closely resembles *A. myriophthalma*, and classed them together as *A. pulvinaria*. In addition, he adopted *A. punctifera* and *A. stellulata* of Lamarck, and *Astræopora fungiformis*, Blainville, which last appears to have been an error, for Blainville described a *Gemmipora fungiformis*, but no *Astræopora fungiformis*.

Dana gave Lamarck's specific name *A. pulvinaria* to specimens collected by the Wilkes Exploring Expedition; but this identification has been corrected by Verrill,† who recognised them as representatives of a new type, *A. profunda*.

In 1849,‡ and again in 1851,§ Milne-Edwards and Haime adopted Blainville's suggested affinity between *Turbinaria* (*Gemmipora*) and *Astræopora*, and united them together with two fossil genera *Dendracis* and *Actinacis* to form a new subfamily, *Turbinariinæ*. The genus *Astræopora* contained one living species, *A. myriophthalma*, and three fossil. In 1860, Milne-Edwards|| added a new fossil genus, *Palæacis*, to the subfamily, and two more living species to the genus *Astræopora*, viz. *A. pulvinaria* and *A. punctifera*, a figure

\* 'Notes, Systematic and Morphological, on the Madreporarian Genus *Turbinaria*,' Ann. and Mag. Nat. Hist. xv. (1895) p. 499.

† Appendix to Dana's Corals and Coral Islands, 1st edition, 1875, p. 333.

‡ C.R., xxix. p. 259.

§ Polypiers fossiles des Terrains palæozoïques, p. 144.

|| Les Coralliaires, iii. p. 164.



(pl. E 2, fig. 4) being given of *A. myriophthalma*. Dana's suggestion that this last species was the same as *A. pulvinaria* was rejected.

The absence of the columella, which is so conspicuous in the *Turbinaria*, was recognised by these authors, for the first time, as the distinguishing feature of *Astracopora*, and led to the suggestion, now fully justified, that *Astracopora stellulata*, which possesses a columella, really belonged to *Turbinaria*. This reduced the known species of *Astracopora* to four, viz. *A. pulvinaria*, *A. myriophthalma*, *A. punctifera* and *A. pulvinaria*, Dana, since recognised as new, viz. *A. profunda*, Verrill.

In 1877, Brüggemann,\* in describing some new Stony Corals in the National Collection, established a new species, *Astracopora expansa*, which is the last recorded addition to the genus.

In 1879, Dr. Klunzinger,† placing the genus with *Turbinaria* in the family *Turbinaridae*, described a species from the Red Sea which he identified with Lamarck's *A. myriophthalma*. A specimen of this coral came into the possession of the Natural History Museum, and is here identified as a new species (*A. Ehrenbergi*). Dr. Klunzinger further identified Ehrenberg's‡ subgenus *Phyllopora* with *Astracopora*; Ehrenberg's two species, *P. leptostoma* and *P. spharostoma*, being two varieties of Klunzinger's (not Lamarck's) *A. myriophthalma*.

In 1886, Quelch, in his report on the Reef Corals of the 'Challenger' Expedition, identified the single specimen of the *Astracopora* contained in the collection as Verrill's *A. profunda*.

At the time of my undertaking to catalogue the Collection in the National Museum, it had been recently enriched by specimens from Tongatabu, collected by J. J. Lister, and from the coasts of Australia, collected by Mr. Saville-Kent. There were in all only thirty specimens, eighteen of which were unnamed.

#### DESCRIPTION OF THE GENUS.

The first buds appear very early, grouped closely round the parent polyp of the colony. The first small disc-like stock thus formed is contained in a common saucer-like epitheca. Budding appears to continue wherever there is space, i. e. round the edge, or between any two existing calices. I have found no direct connection, apart from the canal system traversing the cœnenchyma, between the buds and their parent polyps. The buds appear anywhere on the surface of the cœnenchyma as slight indentations, almost exactly half-way between two existing polyps, and it is impossible to say that they belong more to the one than to the other. There is thus no definite system of budding, and in this respect, the genus *Astracopora* differs from both *Turbinaria* and *Madrepora*, in which specialised methods of budding lead to branching, or cup- or leaf-like stocks.

\* Ann. and Mag. of Nat. Hist. (4) xix. p. 416.

† Korallenthiere des rothen Meeres, Th. II. p. 52.

‡ Beiträge z. Kennt. d. Corallenthiere d. rothen Meeres, 1830; Genus lxx. *Madrepora*, p. 114.

The colonies range in form from flat expanses to globular masses. In the former, new buds are formed, chiefly round the growing edge, while the existing polyp-cavities lengthen but slowly; in massive specimens, the polyp-cavities lengthen rapidly, and, as the intervals between these cavities increase, buds appear between them. These massive growths, increasing in thickness more rapidly than in breadth, reach a stage when the basal regions die, so that, while the top is continually expanding, the base has ceased to grow. These become top-heavy and roll over. The rolled dead portion is then grown over by fresh growths. In this way, globular forms occur which may show no point of attachment.

The whole skeletal mass uniting the polyps, and rising above the basal epitheca, is thus septal or cœnenchymatous. The intracalicular portions of the septa are but very feebly developed, while the extracalicular (costal, cœnenchymatous) portions are well and often strikingly developed.

We may, perhaps, describe the cœnenchyma as being typically built up of two elements, a vertical and a horizontal, in the following way. The costæ stand out round the calicle as tapering echinulæ, sloping upwards all round the aperture of the calicle. These echinulæ, which constitute the vertical or upright elements of the cœnenchyma, may or may not show the primitive connection with the septa. The horizontal element is a series of more or less flat perforated plates, which bind all the uprights together, so that the whole cœnenchyma appears to be composed of tiers of horizontal synapticular floors, supported by columns passing through them.

This typical structure of the cœnenchyma shows great variations. In flat, horizontal coralla, the vertical element may be reduced to thin, irregular pillars, while the horizontal element is very conspicuous, making the whole surface of the corallum look smooth and flat. On the other hand, in globular specimens, or on portions of specimens growing rapidly in thickness, the upright, vertical elements stand high, giving the whole a strikingly echinulate appearance, while the horizontal floors are reduced to small connecting trabeculæ.

Again, both elements may lose their distinctive character, becoming less definitely upright or horizontal, the whole cœnenchyma then forming a reticulum, barely recognisable as belonging to the type. Lastly, by the thickening of the elements into solid, irregular granules, the whole may look like a rough agglomeration of cemented grains with interstices.

The cœnenchyma may assume more than one character on one and the same specimen, according to the position of the part. For instance, in a globular specimen, the uppermost surface, where the corallum is increasing more rapidly in thickness, is a light open reticulum. This gradually changes at the sides and under surface into an almost smooth, continuous synapticular floor, broken only by the calicles and by pores.

The discarded epitheca plays here and there an important part. If the corallum is a flat expanse, the epitheca grows with the growing edge of the corallum, either adherent to a substratum, or freely rising from it. Wherever the epitheca does not keep pace with the outward growth of the cœnenchymatous skeleton, the latter may droop over its edge, or send down long calicular tubes or rootlets, which latter are slowly grown over by the epitheca.

The epitheca may at any time reappear under an advancing creeping corallum. In thick growths, which have died down but are being grown over by a new layer, an epitheca which can have no connection with the original epitheca of the colony, forms under the edge of the new layer. When a layer is creeping down round a globular specimen, the epitheca seeks to hinder the downward movement, at times even bending up over the edge of the advancing corallum, covering up the calicles. This may or may not succeed; if not, it is because the cœnenchymatous skeleton above the upper edge of the epithecal fold becomes so thick that it can roll right over it. As a rule, the tendency of the epitheca is to turn the edge of a corallum upwards. It appears as if the edge of the corallum can only manage to hang downwards by growing faster than the epitheca, and thus rolling over.

Dana has described the living calicles of *A. profunda* as having 24 (or more) tentacles in two series, and as being of a brownish colour. A very common colour for the unbleached corallum is a bright yellowish red or brown.

#### DEFINITION OF THE GENUS.

The genus *Astræopora* may be thus defined: Madreporaria with a purely cœnenchymatous skeleton resting upon a basal epitheca, either spreading with the latter in expanding plate-like growths or rising over it to form solid masses. The cœnenchymatous skeleton is composed typically of costal vertical pillars and of parallel tiers of synapticular floors. The calicles with but feebly developed intracalicular septal laminæ, six only approximating to the centre.

#### ON THE RELATION OF THE GENUS ASTRÆOPORA TO THE GENUS TURBINARIA.

Blainville's suggestion ('Manuel d'Actinologie,' p. 384) that these two genera might without inconvenience be united, was adopted with some hesitation by Dana. This author's note of interrogation, however, did not again reappear, and the two genera have been closely associated ever since, the chief distinction between them being the well-developed columella of *Turbinaria*.

*T. stellulata*, ranked as an Astræoporan by Blainville and Dana, but recognised as a Turbinarian by Milne-Edwards, was supposed to represent a transition form. Ortmann, in his genealogy of the Corals,\* suggests the deduction of *Turbinaria* from *Astræopora*. The present writer† was at one time disposed to consider *Astræopora*, on account of the absence of all specialised method of budding, as a primitive form of cœnenchymatous coral from which first *Madrepora*, and then *Astræopora* through *Madrepora*, might possibly be deduced. As a matter of fact, judging from skeletal structures alone, all we really know, is that the corallum in both *Turbinaria* and *Astræopora*, as also in many other genera, rises above the original epitheca as a purely septal or cœnenchymatous structure. This is the only point

\* 'Beobachtung an Steinkorallen von der Südküste Ceylons,' Zool. Jahrb. Systematik, iv. (1889) p. 586.

† Ann. and Mag. Nat. Hist., xv. (1895) p. 499.



they have in common, while, on the other hand, the texture of the cœnenchyma of *Astræopora* is so peculiar and specialised that it can hardly have been the original form of the cœnenchyma of *Turbinaria*. We are not, therefore, justified in classing *Astræopora* with *Turbinaria*; they must, for the present, be regarded as independent developments of the cœnenchymatous corals, and the striking resemblances between certain forms in the two genera are to be considered as fresh instances of what is known as convergence.\*

#### GEOGRAPHICAL DISTRIBUTION.

Several species of *Astræopora* are recorded from the Red Sea, while specimens have been collected in Mauritius and in the Indian Ocean. In the Torres Straits, on the Great Barrier Reef, and along the north coasts of Australia they occur somewhat scantily, while only a single specimen was discovered by Mr. Saville-Kent on the west coast of Australia. They have further been discovered as far east as the Solomon Islands. None have so far been recorded from the Malay or Chinese Seas. The small number hitherto collected is probably indicative of rarity, but it may also be partly due to their inconspicuous forms.

#### GENERAL REVIEW OF THE VARIATIONS IN FORM AND STRUCTURE ASSUMED BY THE GENUS ASTRÆOPORA.

*Variations in the Form of the Stock.*—The genus may be primarily divided according to its methods of growth. Three more or less distinct types are recognisable:—

1. *Explanate Type.*—The young corallum in its saucer-shaped epitheca expands laterally in all directions, showing no very marked growth in thickness.

Under this head would come primarily Brüggemann's type *Astræopora expansa*, the growth of which appears to be entirely explanate, with hardly any marked growth in thickness. Further, Lamarek's *Astræopora myriophthalma* forms, according to the original description, great plate-like coralla, and therefore belongs here. This latter species may also, however, form great irregular encrusting mounds. But this is apparently not due to regular growths in thickness, but, whether stimulated by parasites or not, to the throwing up of irregular humps. However massive these mounds appear, they can always be distinguished from the following massive types of growth by their irregular surfaces and shape, and by the character of their edges (Plates XXV. and XXVI.).

2. *Pulvinate Type.*—The corallum grows chiefly in thickness, by the rapid lengthening of the calicles. As they shoot up, those at the sides bend outwards, making room for new calicles to appear. The top is thus always expanding, while the lower portions die. Ultimately the expanding top, continually forming new layers, hangs over on all sides like a great bolster or cushion. In transverse section, the calicles appear at first sight to be grouped somewhat like

\* One glomerate Turbinarian from the Tizard Bank (and associated with *T. stellulata*), has even a somewhat similar texture of the cœnenchyma.

the straws in a wheatsheaf, expanding fan-like at the top. Under the drooping edges of the bolster or cushion-like top a secondary development of epitheca is always found. Owing to the death of the lower portions, the base at an early stage ceases to expand laterally, so that the ever expanding top causes the mass sooner or later to become top-heavy and roll over (Plates XXVIII. and XXIX.).

I have borrowed the name pulvinate from Lamarck's species *pulvinaria*, which I at first thought might come into this division. It is true that Lamarck spoke of *A. pulvinaria* as being only a variety of *A. myriophthalma*. This suggestion, rejected by Blainville, was accepted—though reversed—by Dana, and again rejected by Milne-Edwards. It appeared to me at first, that, as Lamarck mixed the *Astræoporæ* with a great number of specimens of totally different genera in his single genus *Astræa*, two *Astræoporans* would naturally appear in such a heterogeneous collection to be very near to one another, and that the suggestion need not be accepted. After a very careful examination of Lamarck's words, I have, however, come to the conclusion that his description of *pulvinaria* ("incrustans, undosa") must apply to specimens showing the explanate type of growth and not the pulvinate. Further, the prominent conical calicles ally it, as Lamarck suggested, with *myriophthalma*. Hence, after having accepted the species *pulvinaria* and made it the type of the pulvinate method of growth, I found myself ultimately compelled to remove it again, borrowing, however, the name "pulvinate" for the division.

3. *Globular Type*.—The corallum commences at once to form a hemispherical mass by the lengthening of the calicles, chiefly in the centre, while at the sides the cœnenchymatous skeleton rolls over the epitheca. At a later stage the corallum forms an almost perfectly globular mass, composed of concentric shells, each being a new layer of growth, starting from some point on the summit and creeping down all round. This division would contain Lamarck's *Astræopora punctifera*, which he describes as being like a small cannon-ball. Lamarck added that his specimen showed no point of attachment. This remarkable statement (though quoted by Dana) has been generally allowed to drop, apparently as being unintelligible. It appears, however, from the specimen in the Natural History Museum which I identify with Lamarck's species, that these globes are, like the pulvinate specimens, liable to break off and roll over; it is, therefore, not difficult to see how the scar of attachment might be grown over in a particular case (Plate XXX.).

#### VARIATIONS PRESENTED BY THE CALICLES.

These show considerable range of variation, in their average sizes, their distribution (crowded or scattered), and in the way in which, when protuberant, they raise up the cœnenchyma conically (cylindrically or hemispherically). The structure of the wall surrounding the aperture of the protuberant calicle is also of importance, as it is closely associated with the character of the cœnenchyma, which is a marked feature in the genus.

The number and character of the septa show also slight differences.

The presence or absence of tabulæ has probably no independent taxonomic value, as it is apparently invariable in the massive types of growth in which the calicles have to lengthen very rapidly. The same phenomenon is found in glomerate Turbinarians.

#### THE VARIATIONS IN THE CŒENCHYMA.

Dana suggested that the genus *Astræopora* might be divided into two groups—perhaps even genera—one having the cœenchyma highly echinulate, and the other more porous and granular. Milne-Edwards adopted this suggested division. But, as we have seen above, these changes are but variations upon that structure of the cœenchyma which is typical of the genus and one of its most marked features. Explanate forms tend to have the horizontal element more pronounced than the vertical costal pillars, resulting in the smoother porous form of cœenchyma, while massive forms tend to have the vertical element more pronounced than the horizontal synapticular element, and are thus more likely to be echinulate. There are, however, other variations in the texture of the cœenchyma, which appear to have a taxonomic value: the echinulæ themselves vary considerably in form and appearance. The texture may be very coarse or delicate, loose or compact. Again, the typical structure may be obscured, the cœenchyma being simply reticular, or solid, or granular.

#### ON THE CLASSIFICATION OF THE SPECIMENS BASED UPON THESE VARIATIONS.

On the general subject of dividing the members composing a genus of corals into species, I refer the reader to what I have said under the similar heading in the Introduction to the Catalogue of Turbinarians.\* In the present case, we have only a small number of specimens to deal with, and when those which are obviously specifically identical, coming from the same locality, have been separated, the small number remaining can easily be described singly as new types, a process which is hardly practicable in a large collection in which the variations shade off into one another by an infinite number of gradations.

As in my classification of the Turbinarians, I have again selected the methods of growth as the leading feature in dividing the specimens. It is, however, not easy to ascertain, in all cases, to which type of growth certain specimens belong. In such cases, I have mentioned this doubt. Beyond this difficulty, the smallness of the Collection allows of its being divided into separate types, without any sense of excessive multiplication of new species.

With regard to the existing types, the usual difficulty in identifying them with actual specimens was, in this case, reduced to a minimum. There were only five recorded species. This number was reduced to four, as soon as I convinced myself that *A. pulvinaria* and

\* *Vide supra*, p. 19.



*A. myriophthalma* of Lamarek were specifically identical. Of these four, the original type of one, *A. expansa* of Brüggemann, belonged to the Collection. To these four established species I have added ten new, here described for the first time. Photographs showing the general methods of growth of each species, and in each case also an enlarged drawing of a calicle, are given in the plates. These illustrate not only the new types, but also the Museum specimens of those older species which I have succeeded in identifying.

LIST OF SPECIES.

I. ASTRÆOPORÆ EXPLANATÆ.

1. *A. expansa*.
2. *A. horizontalis*.
3. *A. myriophthalma*.
4. *A. incrustans*.
5. *A. arenaria*.

II. ASTRÆOPORÆ PULVINATÆ.

6. *A. listeri*.
7. *A. ehrenbergi*.
8. *A. gracilis*.
9. *A. hirsuta*.
10. *A. ocellata*.

III. ASTRÆOPORÆ GLOBULARES.

11. *A. punctifera*.
12. *A. ovalis*.
13. *A. kenti*.
14. *A. profunda*.

## SYSTEMATIC ARRANGEMENT OF THE SPECIES.

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### Group I.—ASTRÆOPORÆ EXPLANATÆ

*In which the corallum spreads laterally, either encrusting or with a free edge supported by an epitheca. The corallum thickens slowly and often irregularly.*

Species 1. *Astræopora expansa*. (Pl. XXV.; Pl. XXXIII. fig. 7.)

*Astræopora expansa*, Brüggemann, Ann. and Mag. Nat. Hist., xix. (1877) p. 416.

*Description*.—Corallum thin and slightly crateriform, the edge rising freely, supported by a well-developed concentrically wrinkled epitheca. As the central region dies, it is grown over by a layer of corallum under which a secondary epitheca appears. The outer margin is about 0.5 cm. thick.

Calicles small (1.5–2 mm.), round, do not project above the cœnenchyma. When the corallum is held up to the light they appear to reach right down to the epitheca. Very irregularly distributed in what appear to have been irregular concentric rows (i. e. as they appeared along the growing edge). These rows may be as much as 1 cm. apart, while along the rows the calicles may be as near as 2 mm. to one another.

The cœnenchyma is composed of nearly continuous horizontal floors supported by fine vertical pillars. The wide interstices between the calicles show either such a smooth floor, or else a floor showing the formation of pillars in all stages of development from simple points to a flat reticulum joining their upper ends and commencing to form a new floor.

The unique specimen on which this species is founded exhibits the extreme explanate method of growth of the genus. It has apparently developed at the edge of a previous growth of the same, continuing the edge outwards on the one hand, and on the other creeping backwards over the dead growth. The specimen cannot rightly be called stalked (cf. Brüggemann), the "short pedicle" being in reality a broken fragment of the previous growth, showing in section the rectangular floor-and-pillar texture of the cœnenchyma. Seen from above, the specimen is kidney-shaped, or even better, ear-shaped.

This form seems to be a simple enlargement by lateral expansion of the youngest known stage of *Astræopora* and of its saucer-like epitheca. The edge of the corallum, supported by the epitheca, rises free from the substratum.

a. Locality not recorded.

[Register No. 58. 12. 17. 6.] (Type.)

Species 2. *Astræopora horizontalis*. (Pl. XXV.; Pl. XXXIII. fig. 8.)

*Description*.—Corallum, a thin, nearly horizontal plate with evenly drooping edges, which are free from the substratum. The margin is so thin as to be almost sharp; it is followed by a well-developed epitheca, but not so closely as in *A. expansa*, hence perhaps the tendency of the edges to droop; the upper surface evenly curved.

Calicles small (1·25 mm.), diminishing in size near the edge, round, star-like, numerous, about the diameter of a calicle apart. For some distance from the thin margin of the corallum the calicles appear to penetrate down to the epitheca. The margins of the individual calicles rise but very slightly above the level of the cœnenchyma as thin rings of granular vertical projections arranged radially, which internally run down continuous with the septal ridges; these projections are joined by a single layer of perforated mural tissue.

The first cycle of septa is well developed and conspicuous, the second is rudimentary, but appears at the edge, and takes part in the formation of the marginal wall.

Cœnenchyma. The interstices are more or less evenly floored with the typical synapticular constituent which is perforated with round pores. The costal system of upright pillars (echinulæ) can be seen in all stages of development, giving the whole corallum to the naked eye a rough granular appearance. Under the glass, the echinulæ are seen to be very irregular in shape and size, with an indefinite whitish fraying of their tips.

The greater part of the single specimen of this new Astræoporan has been apparently killed by an encrusting sponge. Three portions of its horizontally expanding edge were, however, living when it was collected. From its point of attachment it has grown out chiefly on one side as a horse-shoe-shaped expansion, largely free, but touching the substratum here and there. The corallum is a light yellowish brown. It has a colony of small orange-coloured sponges growing upon it.

a. Bird Island, Seychelles (7 fathoms, sand and coral). (Type.)

Species 3. *Astræopora myriophthalma*. (Pls. XXV. and XXVI.; Pl. XXXIII. fig. 9.)

*Astræa myriophthalma*, Lamarek, Anim. sans Vert., ii. (1816) p. 260.

*Astræopora myriophthalma*, Blainville, Dic. Sciences Naturelles, lx. (1830) p. 343.

*Astræopora myriophthalma*, Milne-Edwards and Haime, Les Polypiaires fossiles des terrains paléozoïques, 1851, p. 141; and Les Coralliaires, iii. (1860) pl. E 2, fig. 4.

Non *Astræopora myriophthalma*, Klunzinger, Korallenthiere des rothen Meeres, 1879, p. 52.

*Description*.—Corallum flat, expanding, more or less circular, encrusting, with drooping or horizontal edges. More or less irregularly humped in the older central portions; general aspect coarse; colour of unbleached specimens bright red-brown.

Calicles circular (2 mm. diameter), typically project as thin-walled cylinders (5 mm. high and less), consisting of the ring of exsert septa with their costal echinulations, joined together by a porous mural layer. The echinulations increase in length towards the base of the calicle, where they are joined by trabeculæ, so that unless the calicles are closely crowded there



is a thicker layer of reticulum here than round the margin, and the projections are conical. Long cylindrical calicles hang down from the under surface.

In young, flat specimens, the calicles are fairly evenly distributed, with well-marked interstices, but in older, humped specimens they are often closely crowded, especially on the slopes, so closely that the costal echinulations have no room to develop; the walls are a thin latticework, the exsert septa running out as long tapering spines united by delicate mural trabeculae. The interstices in this case are deep narrow grooves with vertical walls (Pl. XXVI.).

The intracalicular portions of the septa are weakly developed. Two cycles, with traces of a third, appear in the protuberant calicular walls, while far down in the calicles the septa of the first cycle alone become prominent, but do not reach the centre.

Cœenchyma in the young and flat stage shows very definite synapticular floors in well-developed tiers, but as the corallum gets old and humpy, growing irregularly in thickness, the horizontal layers are less and less developed, while the vertical elements become more and more leaf-like and predominant. The interstices are highly reticular and porous.

There are five specimens of this coral which I have identified with Lamarck's original *Astrœa myriophthalma*. Lamarck's description agrees in every detail. The specimens are large encrusting plates, "very rough," with "humpy" surfaces. The growth is distinctly explanate. This identification prevents me from accepting that of Dr. Klunzinger. As far as can be judged from the fragmentary specimen of Klunzinger's *Astrœopora myriophthalma* in the National Collection it shows unmistakably the pulvinate type of growth, and cannot therefore be identified with a species forming large plates with humpy surfaces.

The five specimens, four of which are from Mauritius and the fifth probably from the same place, form an interesting series showing the flat, plate-like growth of the younger specimens with the gradual formation of humps, until the largest specimen is an irregular mass differing so markedly from the younger forms, that but for the transition forms of the series it would have been certainly classed as a new type. The calicles in the largest specimen are crowded, with lattice-like walls, the septa running out into fine tapering spines (these are here and there bent over the aperture in a way not easy to understand). The cœenchyma in this same specimen consists largely of thin leaves standing out thickly crowded. At the edges, the new calicles appear among these leaves as irregularly bounded spaces without, or with very slight traces of septa.

The great mounds which this originally flat coral ultimately forms are due to successive layers, each one humping irregularly in the middle. These layers appear one on the other, each new layer creeping over its dead or dying predecessor. The growing edge of the cœenchymatous skeleton seems generally to grow out faster than does the epitheca, but this does not seem in all cases to cause the edges to droop. Long pendant cylindrical calicles, however, appear on the under surface, sometimes bent in all directions. These are slowly grown over and ultimately closed by the advancing epitheca. I have selected as the type specimen the one which shows best the transition from the flat young to the mound-like adult.

a. Mauritius.

(Type.)

b. Mauritius (old specimen).

c, d. Mauritius (younger flat specimens).

e. Habitat unknown.

[Register No. 93. 7. 1. 17.]

In view of the great amount of variation shown by these specimens of *A. myriophthalma* there is hardly any necessity to consider Lamarck's *Astræa pulvinaria* as a variety of *myriophthalma* as he himself suggested. We may safely assume the two to be specifically identical, Lamarck's description applies better to an encrusting explanate growth somewhat massive and cushion-like (*pulvinata*), but with uneven surface (*undosa*) such as is shown by specimens of *myriophthalma*, than to a form exhibiting what I have called the pulvinate \* type of growth. Further, Dana described a species which he identified as Lamarck's *pulvinaria*; this, however, has been renamed "*profunda*" by Verrill. And, lastly, Milne-Edwards' description of the species "*pulvinaria*" appears to be compounded of Lamarck's and Dana's descriptions, which, as we have just seen, referred to different types.

Species 4. *Astræopora incrustans*. (Pl. XXVII.; Pl. XXXIII. fig. 10.)

*Description*.—A thin encrusting growth, creeping over and hanging nearly perpendicularly down around the substratum. When the epitheca is well developed, the pendant edge turns up; where it is not able to grow as fast as the cœnenchymatous skeleton, the latter hangs down irregularly, imbedding everything that comes in its way.

Calicles round, projecting only on slight prominences or humps; on smooth surfaces, immersed; when projecting, the wall is very irregular, one side often thick, the other thin, or even not developed, so that the calicles face in all directions. The calicles vary greatly in size, from 2·5 to 1 mm. diameter. Two cycles of septa visible at the margin, with indications of a third; the first cycle becomes very pronounced deeper down, almost meeting at the centre. There is great variation in the appearances of the calicles; the last two cycles may be very marked round the margin, dividing it into lobes, or, again, the septa may be barely visible at the margin, only appearing far down, in which case the aperture is nearly round, with slight irregularities. These latter calicles are larger, and may be indicative of rapid growth. The fossa appears slightly conical, especially in the abnormally large calicles which occur in the highest parts of the corallum. The smaller, more flower-like, well-marked calicles are about twice their diameter apart, the larger are more crowded.

The cœnenchyma shows also great variations: between the smaller regular calicles, the synapticular element is well represented, making the texture look solid, the costal element being stout and irregular, giving a rough, granular look to the surface. In regions of more rapid growth, the cœnenchyma is a light, friable reticulum, which tends to be flaky. The vertical costal elements are predominant on the higher portions, the synapticular on the sloping.

There is, unfortunately, only one specimen of this coral. On one side of the mound, all the calicles are small and almost star-like, and on the other, large and round, and it is impossible to say, without comparison with other specimens, which is the typical character of the species. There is reason to think that the former may be the more normal type of calicle, and that the latter is due to abnormally rapid growth. If that could be established by new

\* On the origin of this term from Lamarck's specific name, see p. 83.

specimens, it is highly probable that the specimen would turn out to be only an older and coarser example of the small specimen described above as *A. horizontalis*. It is also to be regretted that the habitat of this coral is unrecorded. This is another reason why it is advisable to keep the specimens apart as distinct species. Both sides of the coral are shown on Pl. XXVII.

a. Locality not recorded.

[Register No. 93. 7. 1. 18.] (Type.)

Species 5. *Astræopora arenaria*. (Pl. XXIX.; Pl. XXXIII. fig. 11.)

*Description*.—Corallum encrusting, forming with the substratum a solid irregular mound. The pendent edges either hanging right down, or turned outwards by a well-developed epitheca.

Calicles very irregular in shape, 2 mm. and under in diameter (new minute calicles budding all over the surface among the older), either immersed or irregularly protuberant, either bluntly conical, or globose, pointing in all directions; protuberant margin, irregularly granular and jagged. Two cycles of septa very irregularly developed as slight ridges, sometimes apparent only near the margin. Here and there, however, the primaries are well developed.

Cœenchyma solid, rough and granular. The two typical elements, costal and synapticular, greatly disguised by their thick nodulated appearance, although, here and there, the typical echinulations and floors can be well made out. General appearance as if built up of sand-grains cemented together with varying compactness.

The single specimen of this new type, which is named after the character of its cœenchyma, is a high mound, nearly regularly rounded at the top, while the pendent edges show a tendency to turn outwards. These creeping edges show clearly that the species belongs to the explanate type of growth, but at the same time the specimen shows an affinity with the globular members of the genus. There is, unfortunately, no section exposed, but, judging from the great relative height of the mound, and also from the fact that young calicles appear in all the interstices between the larger calicles, we may safely conclude that the corallum is increasing in thickness at the centre with great rapidity, the existing calicles lengthening and separating as they lengthen, making room for new ones to develop. This allies the form with the globular members of the genus, while the turned-out edges ally it with the explanate forms. In the true globular forms, the epitheca seems no longer to have the power of turning the advancing edges of the corallum outwards; the corallum thickens not only at the centre, but also at the edges, rolling over and depressing the epitheca.

The specimen, coming from the Red Sea, was labelled *Astræopora myriophthalma*, Lamarck, but it is very distinct from the specimens above identified as Lamarck's *myriophthalma*.

a. Red Sea.

(From the Paris Museum, as *A. myriophthalma*, Lamarck.) (Type.)



Group II.—ASTRÆOPORÆ PULVINATÆ.

*Those forms in which the calicles rise up like a sheaf of corn above the epitheca, the top expanding and hanging over. Under the pendent edges of the expanded bolster-like top, a secondary epitheca may appear. This expanded top is grown over by fresh layers, until great, smooth, cushion-shaped masses are formed.*

Species 6. *Astræopora listeri*. (Pls. XXVIII., XXIX.; Pl. XXXIII. fig. 12.)

*Description.*—Corallum showing the typical pulvinate type of growth. The large cushion-shaped masses of the adult often developed from the dead fragments of previous growths which have been overturned. Secondary epitheca often well developed under the new layer forming at any time the expanded top.

Calicles crowded, young ones appearing in almost every available space; generally circular, averaging 2 mm.; slightly protuberant, with thick echinulate walls, often developed only on one side. When fully developed, globose or even almost cup-shaped, the echinulæ being bound together by trabeculæ. Three cycles of septa, of which the primary and sometimes also the secondary may be well developed. The former, on nearing the centre, curl and break up into filaments which may interlace. The connection between the costal echinulæ and the septa is very marked in the marginal walls of the calicles, when protuberant. In regions of rapid growth, the calicles may all be immersed in a light reticulum, their walls being thin and membranous. The youngest are minute membranous pits with no signs of septa. In sections, the great growth in thickness and consequent lengthening of the polyp-cavities leads to the frequent formation of tabulæ which may form continuous horizontal lines 2 to 3 mm. apart through the whole corallum, dividing it into tiers.

The cœnenchyma shows great variations, according as the calicles are specially crowded and rapidly growing, or not. When crowded, the interstices run like a network of deeply engraved lines, which, however, may be almost filled up with a light reticulation showing no traces of the typical cœnenchymatous texture of the genus. As a rule, the costal elements are more prominent than the synapticular, which appear reduced to simple trabeculæ. No continuous floors are distinguishable in the interstices. The more typical echinulæ run out at their tip into minute spines. Cœnenchyma as a rule delicate, may, in large specimens, be very coarse.

I was at first inclined to look upon the specimens on which the above description is based as identical with Lamarek's *Astræa pulvinaria*. As already stated, I was ultimately compelled to accept Lamarek's statement that *A. pulvinaria* was perhaps only another form of *A. myriophthalma*. His description of *A. pulvinaria* shows that it belonged to the explanate forms which are very distinct from the large bolster or cushion-shaped growths of the type now under discussion.

While, therefore, I have adopted Lamarek's name pulvinate to denote a special form of

growth, his species *pulvinaria* belongs to another and less specialised, viz. to the explanate method of growth.

There are in all ten specimens, some of the smaller of which are apparently fragments of a large growth. They are all from Tongatabu. The largest is a smooth, cushion-shaped mass resting upon the edge of an overturned dead mass of the same coral. Sections of some of the broken specimens reveal very beautifully the manner of growth. The calicles rise nearly straight up from their bases, those at the sides, however, soon bending outwards. This continued bending outwards of a certain number of calicles makes room for new ones to appear in the middle. In this way, the top continually expands. The sides of the growth on which the calicles first bent outwards opened, die progressively upwards and are grown over by a film not unlike an epithecal covering and perhaps physiologically identical, though hardly morphologically. The uppermost layer remains alive and greatly expands, bulging out on all sides over its dead pedestal. This layer is again continually covered with fresh layers, ultimately becoming top-heavy and rolling over.

The specimens fortunately contain a complete series showing all the stages of growth here sketched.

Three specimens show the starting into fresh life of broken, overturned fragments. In one case [Register No. 91. 3. 6. 95.], the fragment has started growing on opposite sides, and affords another interesting illustration of the striking variations in one and the same specimen, to be attributed evidently to different conditions of growth. If the two growing patches were not parts of the same specimen, they would never be thought to belong to one and the same species.

a. Tongatabu.

J. J. Lister, Esq. (Type.)

b-j. Tongatabu.

J. J. Lister, Esq.

Species 7. *Astræopora ehrenbergii*. (Pl. XXXIII. fig. 15.)

*Astræopora myriophthalma*, Klunzinger (non Lamarck), Korallenthiere des rothen Meeres, ii. (1879) p. 52.

*Phyllopora sphaerostoma et leptostoma*, Ehrenberg, Korallenthiere des rothen Meeres, 1834, p. 114; vide Klunzinger, l.c.

*Description*.—Corallum shows the pulvinate type of growth.

Calicles slightly protuberant along the top of the ridge; the protuberances irregularly hemispherical, here and there coalescing, owing to their irregular distribution. On the overhanging portions of the expanded top, the calicles tend to be smaller and more star-like, 1 to 1.5 mm., as compared with 2 to 2.5 mm. along the top. The margin of the calicle is a rough, jagged reticulum, or a ring of erect spines ending in fine points and connected by trabeculae. The twelve septa appear at the margin and descend as well-marked ridges in two distinct cycles; deep down, the primaries throw out interlacing processes, which, when well developed, may together fill up the central region of the fossa.

The coenenchyma is evenly echinulate, the echinulae crowded, short, and thick round the slopes of the calicles, finer in the interstices. All alike end in irregular groups of fine diverging points. The floors in the wider interstices with large pores, but evenly developed in regular tiers. In section, the two typical elements, costal and synapticular, are beautifully

and regularly developed, the former being somewhat more pronounced. Sections further show a regular tapering of the costal vertical elements: as they slope away from the walls of the calicles they are thick, but get thinner and thinner, eventually ending as thin pillars to the floors in the interstices.

As is typical in this method of growth, the lengthening calicles develop tabulæ at irregular intervals, from 1 to 2 mm. apart.

There is a single specimen of this coral, a fragment, but fortunately large enough to reveal unmistakably the method of growth. It was one of Dr. Klunzinger's collection, and was named by him *Astræopora myriophthalma*, Lamarck. Judging, however, from this fragment, and from Dr. Klunzinger's description, it belongs to the pulvinate, not to the explanate, division. The great, smooth, rounded top, with downward growing edges, the great length of the calicles and regular increase in thickness of the cœnenchyma confirm this view, and remove the species entirely from *myriophthalma*, with its plate-like corallum, with its edges often extending freely outwards, and its humpy, irregular surface. However well these specimens seem to agree with Lamarck's description of *myriophthalma* when seen entirely alone, when compared with a number of different forms they have to give place before others which agree still more closely with the original description.

This type might almost have been named after the exquisitely delicate and regular texture of its cœnenchyma, as seen in section. I have named it after Ehrenberg, with whose species *Phyllopora* (in two varieties, *sphaerostoma* and *leptostoma*) Dr. Klunzinger, who had access to Ehrenberg's types, has identified it.

Dr. Klunzinger described these corals, when living, as being conspicuous, even from a distance, by their brilliant greenish-yellow colouring.

*a.* Koseir.                      { From Dr. Klunzinger's collection } [86. 10. 5. 33.] (Type.)  
  { as *A. myriophthalma*, Lam. }

Species 8. *Astræopora gracilis*. (Pl. XXIX.; Pl. XXXIII. fig. 14.)

*Description*.—Corallum showing pulvinate method of growth, the expanding top like a thin encrusting layer, the edges of which may be restrained by an epithecal fold.

The calicles small, well defined, circular (1·25 mm.), opening on solid-looking papillar projections (sometimes 3 mm. high), very irregularly distributed, facing in all directions, crowded and confluent, or with deep valleys between. The margin of the aperture is granular, showing indication of the septa which, however, are hardly visible, until deep down in the fossa the six primaries project, as thin irregular plates, which do not meet in the centre.

Young calicles, in all stages of development, in the valleys.

Cœnenchyma. The whole surface of the corallum is very uneven, owing to the irregular groupings of the prominent calicles and the varying depths of the intervening valleys; but it is evenly covered in all parts by echinulæ, crowded, short, longitudinally striated, truncated at the top, but sending up a few fine points; these are thicker on the calicles than in the valleys. A thin, porous, horizontal floor is visible in the valleys.



This unique specimen, distinguished from all others in the Collection by the delicacy and regularity of its surface ornamentation, is fractured across, and reveals a section, 11 cm. thick. From this section the arrangement and great lengthening of the calicles in the pulvinate type of growth can be well seen. The calicles develop tabulæ about 1 mm. apart. The costal element of the cœnenchyma is more strongly developed than the synapticular, the echinulæ tapering and bending upwards, as, in the course of growth, they get further and further from the calicle on whose wall they originally appeared.

The specimen is further remarkable for the presence of a great number of minute tubicolous worms whose usually pink calcareous tubes grow upwards among the lengthening calicles to open on the living face of the corallum. The coral seems to have become adapted to its invader, for there is no sign of abnormal growth immediately round the worm tubes, showing disturbance of the normal conditions, as there is in the case of *Astræopora kenti* (p. 98).

a. Solomon Islands.

Dr. Guppy. (Type.)

Species 9. *Astræopora hirsuta*. (Pl. XXXIII. fig. 13.)

*Description*.—Corallum showing the pulvinate type of growth, a well-developed secondary epitheca on the under surface of the pendent edges.

Calicles so slightly and regularly projecting that the surface appears even; crowded, less than their diameters apart, conspicuous, irregularly circular (ca. 2.5 mm.). Two cycles of septa, the primaries meeting in the centre, deep down in the fossa (5–6 mm.) but not fusing. At the pendent sides, the calicles are shallower and the septa well marked. In the light reticular margins of the slightly protuberant calicles, the primitive connection between the septa and the reticulum is quite obscured. On the summit of the growth, the interstices are pitted with young calicles which first appear as irregular breaks in the reticulum. Tabulæ develop in the lengthening calicles.

The cœnenchyma differs from that of any other type. The synapticular floors along the summit of the coral are either very slightly or very slowly developed, so that the costal elements, the echinulæ, stand up in the valleys like long, slender, but irregular bristles, ending in a single point or in two points, but not in a group of fine points. This character of the cœnenchyma ceases near the pendent sides, where the synapticular floors are more developed, and the echinulæ are short, irregular, and jagged. In section, while the vertical element is very pronounced, the synapticular is but feebly developed, and does not form the regular tiers of floors characteristic of the genus.

There is, unfortunately, only a single fragment of this coral. It is, however, sufficient to reveal the method of growth, and to show the characters, above described, which constitute it a new type.

a. Rocky Islands, Great Barrier Reef.

Saville-Kent Coll. (Type.)

Species 10. *Astræopora ocellata*. (Pl. XXIX.; Pl. XXXIII. fig. 16.)

*Description*.—Corallum, a thick encrusting growth with expanding top. Well-developed (? secondary) epitheca.

Calicles crowded, projecting, globose, with large circular apertures (3 mm.), diameter of protuberance 6 mm. In almost every depression between the crowded protuberances is a deep, pit-like young calicle. Septa very inconspicuous, not showing in the margin, but seen as faint ridges just below it; deep down in the fossa, the frilled edges of the primaries occupy the centre. The hemispherical protuberant calicles are solid and very conspicuous.

Cœnenchyma. Owing to the deep pit-like young calicles between the prominent adult polyp-cavities, it appears almost as if there were no intervening cœnenchyma, the whole corallum looking as if made up of a bundle of thick-walled polyps. The echinulæ are well developed, thick, long, and ending in several spines; the whole has a rough look. The synapticular floors are distinct, but delicate as compared with the stout costal element. Round the margins of the calicles, the cœnenchyma is a solid, apparently irregular reticulum.

It is somewhat difficult, from the material at hand—one specimen and a worn fragment—to ascertain the exact method of growth. That it is mainly a growth in thickness is, however, evident, as well from the section as from the development of new buds all over the surface. We further find tabulæ, which places this point beyond doubt. But whether the growth of the coral conforms to the typical pulvinate or globular method, or to neither, I cannot well decide for certain. On the whole, the method of growth is nearer to the pulvinate type.

The fragment shows some striking differences from the complete specimen. These, however, may be due to wear; the most important is the regular radiation of the costæ as wavy lines down the slopes of the prominent calicles. On the other hand, the *general* resemblance of the specimens, and the comparative nearness of their respective localities (both practically on the northern coast of Australia) are sufficient justification for classing them provisionally together.

*a.* Warrior Island.

*b.* (Worn fragment.) Baudin Island  
(14° 8' S.; 125° 36' E.).

(Type.)

The Lords of the Admiralty.

## Group III.—ASTRÆOPORÆ GLOBULARES.

*The calicles lengthen and increase in number in such a way that the cœnenchymatous skeleton early rolls over the edge of the epitheca, forming at first a hemispherical, and later, as new layers cover the old, an almost completely globular mass.*

Species 11. *Astræopora punctifera*. (Pl. XXX.; Pl. XXXIII. fig. 18.)

*Astræa punctifera*, Lamarck, Animaux sans Vert., ii. (1816) p. 260.

*Astræopora punctifera*, Blainville, Dic. d. Sci. Nat., lx. (1830) p. 348.

*Description*.—Corallum an almost smooth globe, the living layer growing round, closely applied to the previous growth; the edge either arrested by a fold of epitheca or rolling over the epitheca, which thus fails to arrest it. Where the epitheca forms folds over the advancing edge, it covers up the calicles. The core of the globe consists of previous concentric growths, some of which may have been detached and rolled over.

The calicles small and insignificant, immersed, valleys, however, occurring here and there. The fully developed calicles are uniform in size, 2 mm., circular, with irregular margins, crowded, being less than their diameter apart. Young calicles appear in all interstices wide enough, as circular pits, lined with smooth membranous mural tissue with no traces of septa.

In the adult calicles, six primary, very delicate septa are distinct, which almost meet in the centre. Two other cycles are indicated, especially around the margins of certain calicles which are separated by valleys, and thus surrounded with a thick rampart of reticulum; in these, the costal elements of three cycles of septa radiate almost symmetrically outwards.

The cœnenchyma is a rather fine, solid reticulum, looking somewhat granular owing to the short echinulæ not ending in groups of fine minute spines, but rounded off at the ends. Over the surface, while the costal element is distinct, the synapticular floors are only represented by trabeculæ. In the broken sections of earlier growths, the costal element is by far the more important, although the synapticular element is arranged in perfectly regular tiers.

The lengthening calicles form tabulæ.

There is only one specimen of this coral, which bears a close general resemblance to the largest specimen of *A. listeri* in the Collection. It differs, however, from this type both in the characters of its calicles and of its cœnenchyma, as well as in the manner of its growth. At the same time, it is obvious that the pulvinate type of growth might easily pass into the globular, and it is often not easy to say whether a particular specimen belongs to the one or to the other.

The specimen tallies well with Lamarck's description, although the habitat is different. It further fully explains how Lamarck's specimen could be like a cannon-ball, without any apparent point of attachment. It is worth noting that this point in Lamarck's description, though repeated by Dana, was dropped by Milne-Edwards. The single specimen in the National Collection, however, shows how liable these great spherical (and therefore top-heavy)



masses are to be rolled over, while the living layer at the surface is always creeping downwards. It is thus not only quite possible, but very probable, that a recently detached specimen might, when found, have its point of attachment completely grown over.

*a.* Great Barrier Reef.

Saville-Kent Coll. 92. 12. 1. 418.

Species 12. *Astræopora ovalis*. (Pl. XXX. ; Pl. XXXIII. fig. 17.)

*Description*.—Corallum, seen from above, symmetrically egg-shaped, but flattened on its lower side. The living layer almost meets on the under surface, so that the corallum appears to be free and unattached. The epitheca appears under the edges of the enveloping layer of living coral.

Calicles crowded, very large and conspicuous, circular, 3 mm. in diameter, projecting with irregular margins, one side often thick and reticular, the other thin and membranous. In the thicker portions of the margins, the primitive radial symmetry of the costæ is completely obscured. Three cycles of septa appear at the margin, the primary being from the first distinct, and, deep down, projecting so as to appear to meet in the centre.

Young calicles appear in the bottoms of the depressions between the large calicles, as irregular holes in the reticulum.

The coenenchyma shows striking variations; it is coarsely reticular on the uppermost parts of the corallum, but on the sides and under surfaces, the interstices are almost smooth synapticular floors, conspicuous on account of their comparative freedom from echinulæ or pores. The calicles projecting above these smooth floors are often walled round by membranous rings.

This unique specimen (previously labelled *A. pulvinaria*, Lamarek, which it certainly cannot be) is interesting, because it shows an extreme of the globular method of growth. The living coral almost completely envelops it. It lies free, but is hindered from rolling by its flattened under surface. Its almost perfect symmetry of form, and its conspicuous calicles distinguish it completely from all the other specimens in the Collection. Further, the contrast between the open reticulum of the upper portions of the corallum, and the smooth, continuous synapticular floors at the sides and lower portions, is more striking than in any other form. It is difficult to avoid suggesting that the continuous concentric floors in the parts where they are developed (viz. sides and under surface) are physiologically adaptations to restrain the free flowing of the nutrient fluids, under the action of gravitation; such a flowing would tend to destroy the symmetry which we assume to be typical of the species.

*a.* Locality not recorded.

(Type.)

Species 13. *Astræopora kenti*. (Pl. XXX. ; Pl. XXXIII. fig. 19.)

*Description*.—Corallum irregularly hemispherical, the living layer covering a previous growth like a cap; epitheca obscured.

Calicles crowded, small, 2 mm., protuberant, thin walled, and about 2 mm. high on uppermost portions of the corallum, but thick walled, papilliform, and 3 to 4 mm. high on the

sloping sides of the corallum. In the interstices are many full-sized calicles, either immersed or with thin, membranous or lattice-like walls. On both thin and thick walls, the trabecular elements well developed; the costal echinulæ, which are not well developed on the thin-walled calicles and tend to end bluntly, are, however, short, stout, with jagged tips on the taller and thicker calicles. This change in the echinulæ in the lateral and lower regions, alters in these parts the whole aspect of the corallum. Septa not conspicuous; two cycles, the primaries delicate, not meeting in the centre.

Young calicles appear in the valleys.

The cœnenchyma is chiefly remarkable for the conspicuous development of the interstitial porous floors; the echinulæ being comparatively feebly developed. Only immediately round the tall echinulate calicles and on the under surface are the synapticular floors obscured.

This, which was the only *Astræopora* found by Mr. Saville-Kent on the west coast of Australia, and must be considered a great rarity, is, unfortunately, only represented by one specimen. It is of a bright yellow colour, and in its whole appearance distinct from all the other representatives of the genus in the National Collection. In horizontal outline, it is an oval, 11 cm. across, 12 cm. long, and it stands about 8 cm. high. Underneath it is filled up with a dead mass, probably of an earlier growth, which looks as if it had been rolled over. The sections show the synapticular elements of the cœnenchyma well developed in regular continuous floors.

The corallum is perforated by a few of the delicate red worm tubes opening on the surface, which are so marked in *Astræopora gracilis* (p. 94); but in this case, the growth of the corallum seems to have been injuriously affected immediately round the tubes, whereas the former species seems to be completely adapted to the Annelidan intruder.

a. King's Sound, West Australia.

Saville-Kent Coll. (Type.)

Species 14. *Astræopora profunda*. (Pl. XXX.; Pl. XXXIII. fig. 20.)

*Astræopora pulvinaria*, Dana (non Lamarck), Zooph., p. 415, pl. xxix. figs. 3, 3a, 3b, 3c.

*Astræopora profunda*, Verrill, Appendix to Dana's Corals and Coral Islands, 1875, p. 333.

*Astræopora profunda*, Quelch, Chall. Rep. Reef Corals, 1886, p. 169.

*Description*.—Corallum glomerate, often globose, "incrusting," sometimes with an undulating surface.

Calicles nearly hemispherical and continuous at base, sometimes nearly obsolete, at others conoido-hemispherical, crowded here, and distant there, 1.5 mm. diameter.

Cœnenchyma very porous, "pulvinato-echinulate" (*sic* Dana). Fiji Islands.

There is one specimen in the Collection which agrees fairly well with this description. It is a long, flattened oval mass growing round ("incrusting") a previous growth which has been rolled over. There appear to have been four growths, the mass having been overturned during the second.

Dana's figures are not very good, but, taken together with his description, they apply to this specimen; in addition, I may add the following particulars. A well-developed epitheca restrains the downward flow of the growing edge. The septa are in two well-developed cycles, appearing at the margin more markedly than is typical in *Astræopora*, and in the depths of the fossa almost meeting in the centre. Young calicles in the valleys show, even at an early stage, the formation of the septa, which is also not common in the budding calicles of *Astræopora*, which are usually smooth, membranous pits, or mere breaks in the coenenchyma.

The surface of the corallum is indented by shallow valleys, the echinulæ crowded, pronounced, but regularly developed. They are thin, flat plates, running out distally into points; here and there they may be so twisted and joined together as to form a flaky reticulum. Dana's description, "pulvinato-echinulate," is very difficult to understand; on the other hand, his figure 3*b* shows a form of echinula which might perhaps represent a plate with a jagged edge. The synapticular floors are well developed, with large pores.

Dana's figure 3*b* indicates the septa meeting in the centre, but he gives nine so meeting instead of six, whereas in Astræoporans, as a rule, twelve septa are visible, of which six alone approach the centre. But with regard to this point, his reference to the septa in his description is so slight that we are almost justified in concluding that he laid no stress upon their number.

Dana describes and figures the living calicles with twenty-four or more tentacles in two series, and of a brownish colour.

In addition to the specimen here referred to, there is another specimen from the 'Challenger' Collection, which was placed under this heading by Quelch. As far as his description goes, it appears to agree with the above.

*a.* Great Barrier Reef.

Saville-Kent Coll.

? *b.* Banda.

H.M.S. 'Challenger.'

In addition to the Astræoporans above described, there is a young growth which differs from all the others, and which may be that of a new type. It is so young that its distinctive features are not yet developed.

It is closely incrusting, having no free edges; the epitheca adherent everywhere to the substratum. It may perhaps be a young stage in the globular method of growth.

The calicles project as cylinders formed by the exsert septa (sometimes carrying echinulæ) bound together by membranous mural tissue. The septa rise right to the margin, so that the aperture is often flower-like. The most marked feature of the coenenchyma is the conspicuous smooth glistening synapticular floors, continuous, and with very few pores. The echinulæ are also not numerous. These features may be due to the youth of the specimen.

The specimen was labelled *A. myriophthalma*, Lamarck, but standing alone as it does, unconnected by any series with other specimens, it is not possible to ascertain its true place in the genus.

*a.* Young specimen, sp. ?, locality not recorded.

[Register No. 93. 7. 1. 19.]





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[Figures in black type refer to pages on which the descriptions will be found.]

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## EXPLANATION OF THE PLATES.

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### PLATES I.-XXX.

[Collotype reproductions of photographs.]

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A large specimen of *Turbinaria crater*,  $\times \frac{1}{2}$ .

#### PLATE II.

The Type specimen of *Turbinaria danæ*,  $\times \frac{1}{2}$ , slightly from above.

#### PLATE III.

The Type specimen of *Turbinaria edwardsi*,  $\times \frac{1}{2}$ , seen from above.

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The Type specimen of *Turbinaria aurantiaca*,  $\times \frac{2}{3}$ , seen from above.

„ „ *Turbinaria plicata*,  $\times \frac{2}{3}$ , seen from above.

„ „ *Turbinaria undata*,  $\times \frac{2}{3}$ , seen from above.

„ „ *Turbinaria laminata*,  $\times \frac{2}{5}$ , seen from above.

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The Type specimen of *Turbinaria speciosa*,  $\times \frac{1}{2}$ , from the side.

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The Type specimen of *Turbinaria nidifera*,  $\times \frac{2}{3}$ , seen from above.

„ „ *Turbinaria abnormalis*, seen from above.

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A young specimen of *Turbinaria peltata*, from the side.

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## PLATE VIII.

An encrusting specimen of *Turbinaria peltata* (Shark's Bay),  $\times \frac{1}{2}$ , from the side.

„ „ „ *patula*,  $\times \frac{1}{2}$ , from the side.

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A stalked specimen of *Turbinaria patula* (Torres Straits),  $\times \frac{1}{2}$ , from above.

The Type specimen of *Turbinaria radicalis* (Great Barrier Reef), from the side.

The Type (stalked) specimen of *Turbinaria agaricia* (Torres Straits),  $\times \frac{1}{2}$ , from above.

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The Type specimen of *Turbinaria calicularis*  $\times \frac{1}{2}$ , from the side.

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„ „ *Turbinaria venusta*, fragment of old stock seen slightly from above, with young specimen from the side,  $\times \frac{1}{3}$ .

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- The Type specimen of *Turbinaria rugosa* (Formosa), seen slightly from the side,  $\times \frac{2}{3}$ .

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 A fragment of large stock of *Turbinaria stellulata* (Tongatabu), from the side,  $\times \frac{3}{4}$ .  
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 The Type (stalked) specimen of *Turbinaria dendrophyllia*,  $\times \frac{3}{5}$ , from above.

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- Gigantic stock of *Turbinaria conspicua* (Shark's Bay),  $\times \frac{1}{5}$ .

## PLATE XXIII.

- Five specimens showing stages in the growth of *Turbinaria gracilis* (Gulf of Carpentaria),  $\times \frac{1}{3}$ .

## PLATE XXIV.

- The Type specimen of *Turbinaria contorta* (South China Seas),  $\times \frac{2}{3}$ .



## PLATE XXV.

The Type specimen of *Turbinaria subversa*,  $\times \frac{2}{3}$ , showing the stalk grown round a portion of the substratum.

The Type specimen of *Astræopora expansa*,  $\times \frac{1}{3}$ , seen from above.

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The type specimen of *Astræopora ovalis*, from above, about natural size.

A globular specimen of *Astræopora punctifera* (Great Barrier Reef),  $\times \frac{1}{3}$ , seen slightly from below, to show the previous growths and the epitheca.

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A specimen of *Astræopora profunda*,  $\times \frac{1}{2}$ , from the side.

## PLATES XXXI.-XXXIII.

Lithographed drawings of enlarged calicles, showing details described in the diagnoses of the species.

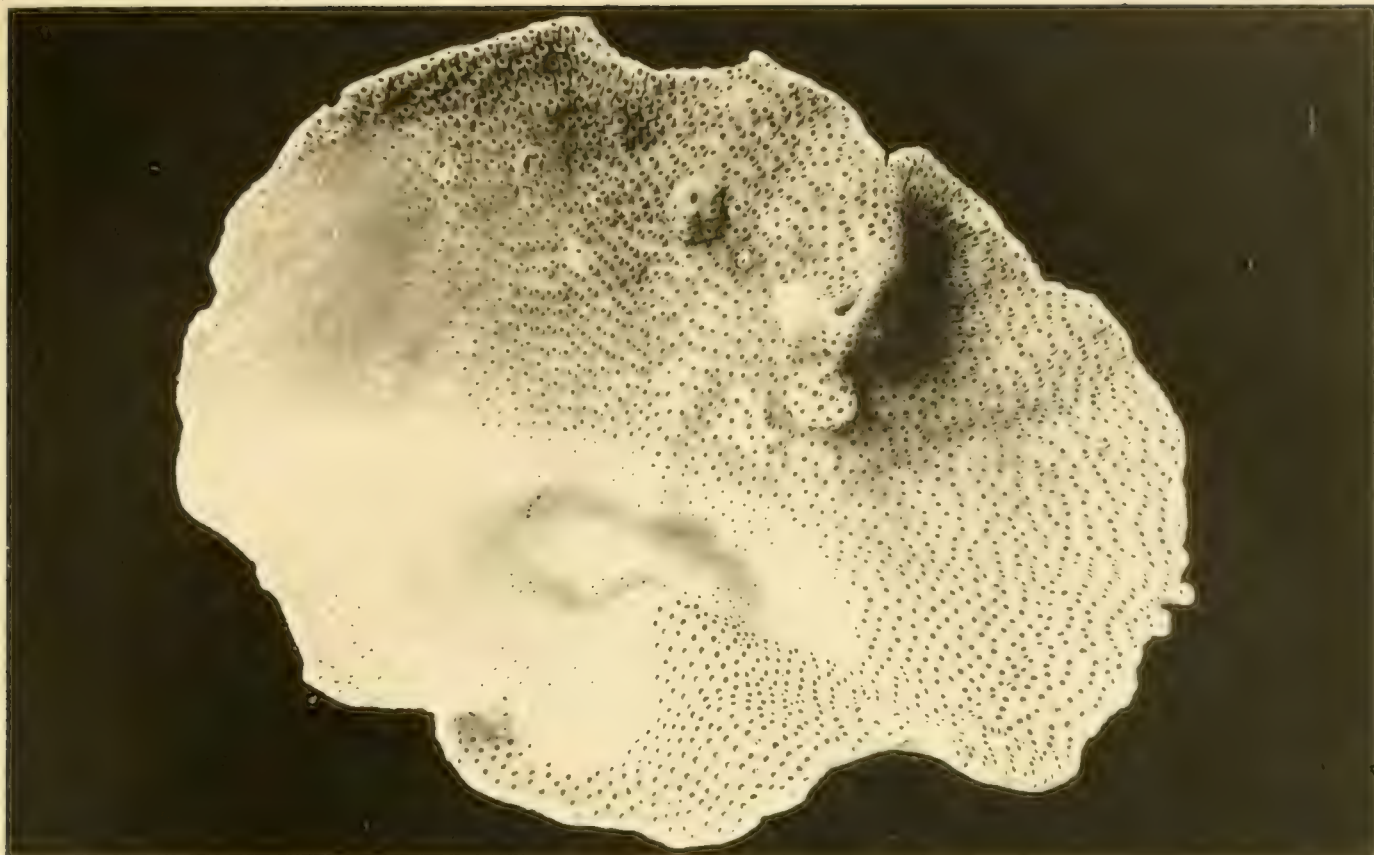












TURBINARIA EDWARDSI  $\times \frac{1}{2}$



TURBINARIA PUSTULOSA  $\times \frac{1}{2}$

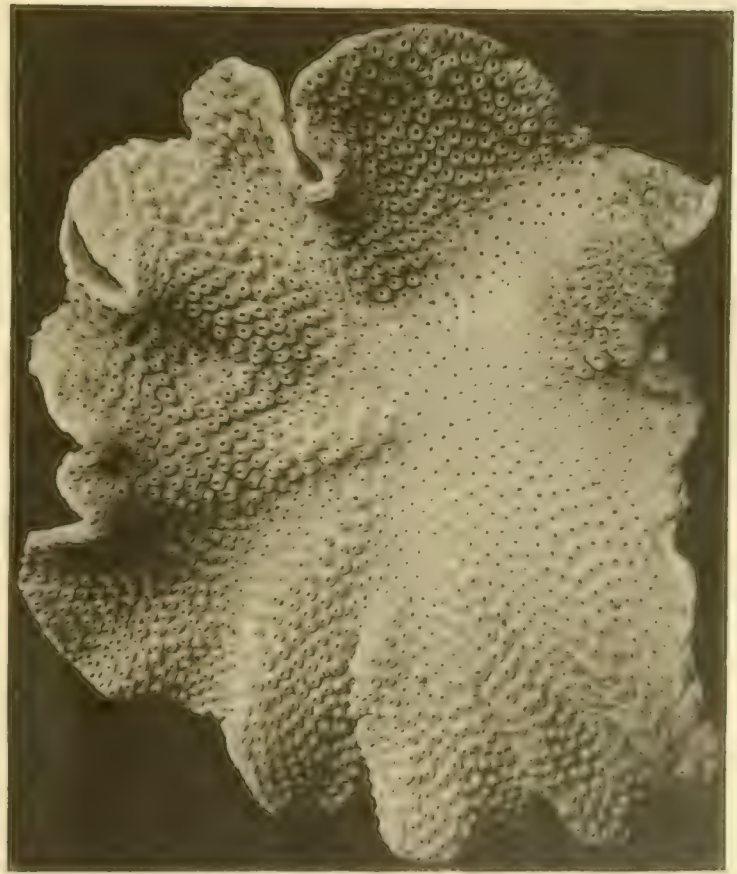






*TURBINARIA ACANTHATA* × 1

*TURBINARIA ELEVATA* × 1



*TURBINARIA ACANTHATA* × 1

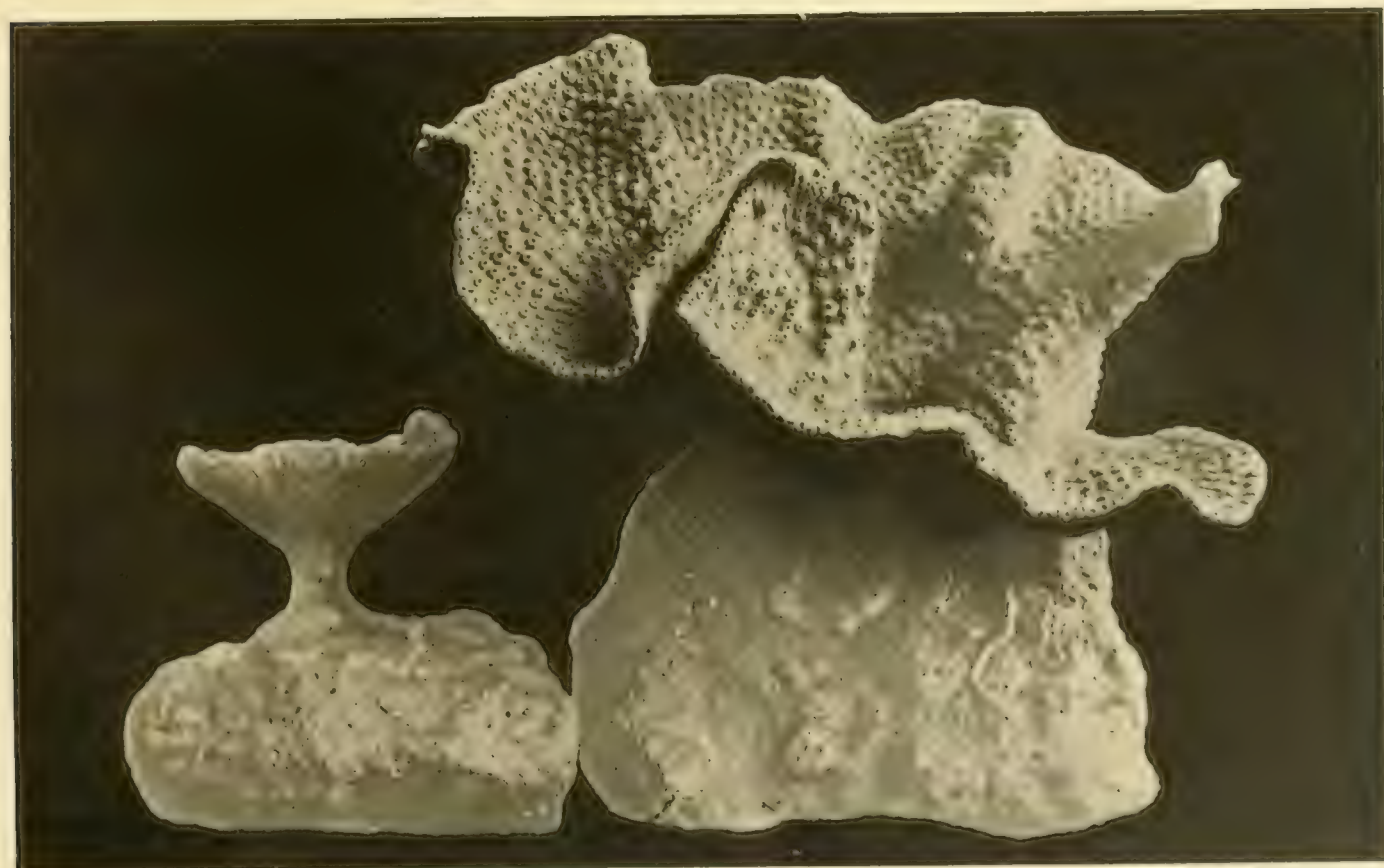
*TURBINARIA ELEVATA* × 1







TURBINARIA SPECIOSA  $\times \frac{1}{2}$

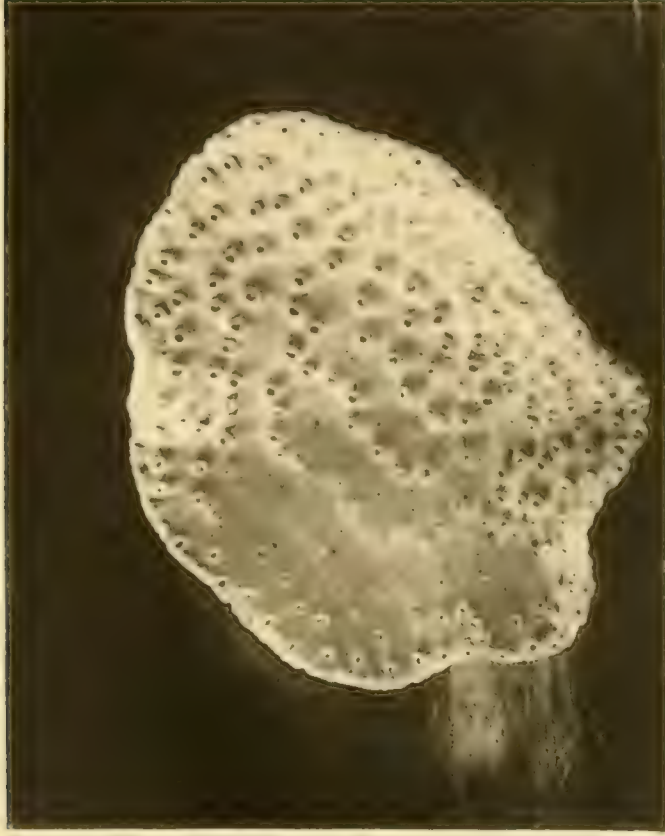


TURBINARIA MOLLIS  $\times \frac{2}{3}$





TURBINARIA NIDIFERA  $\times 3$



TURBINARIA ABNORMALIS



TURBINARIA POCILLIFORMIS



TURBINARIA PELTATA



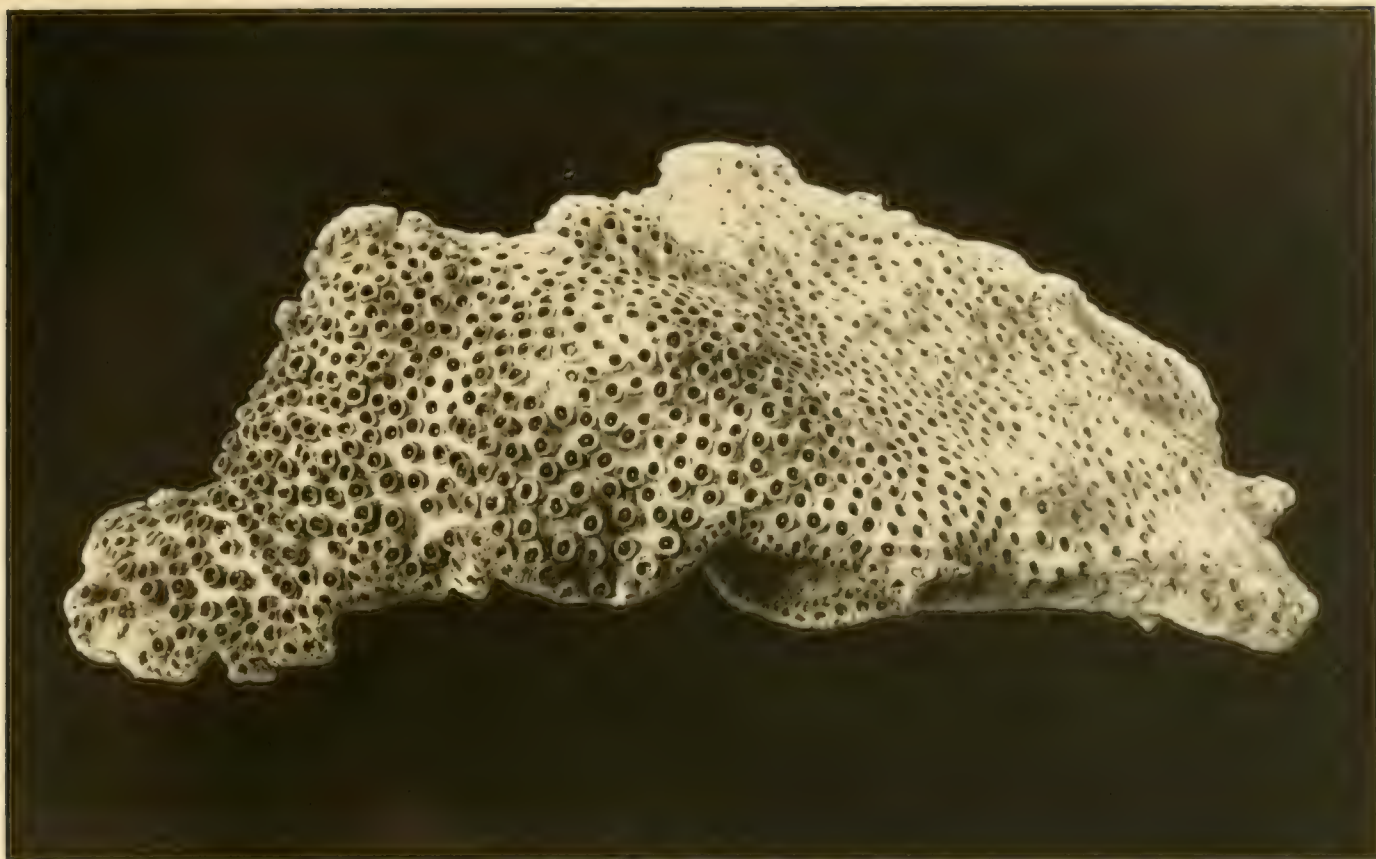




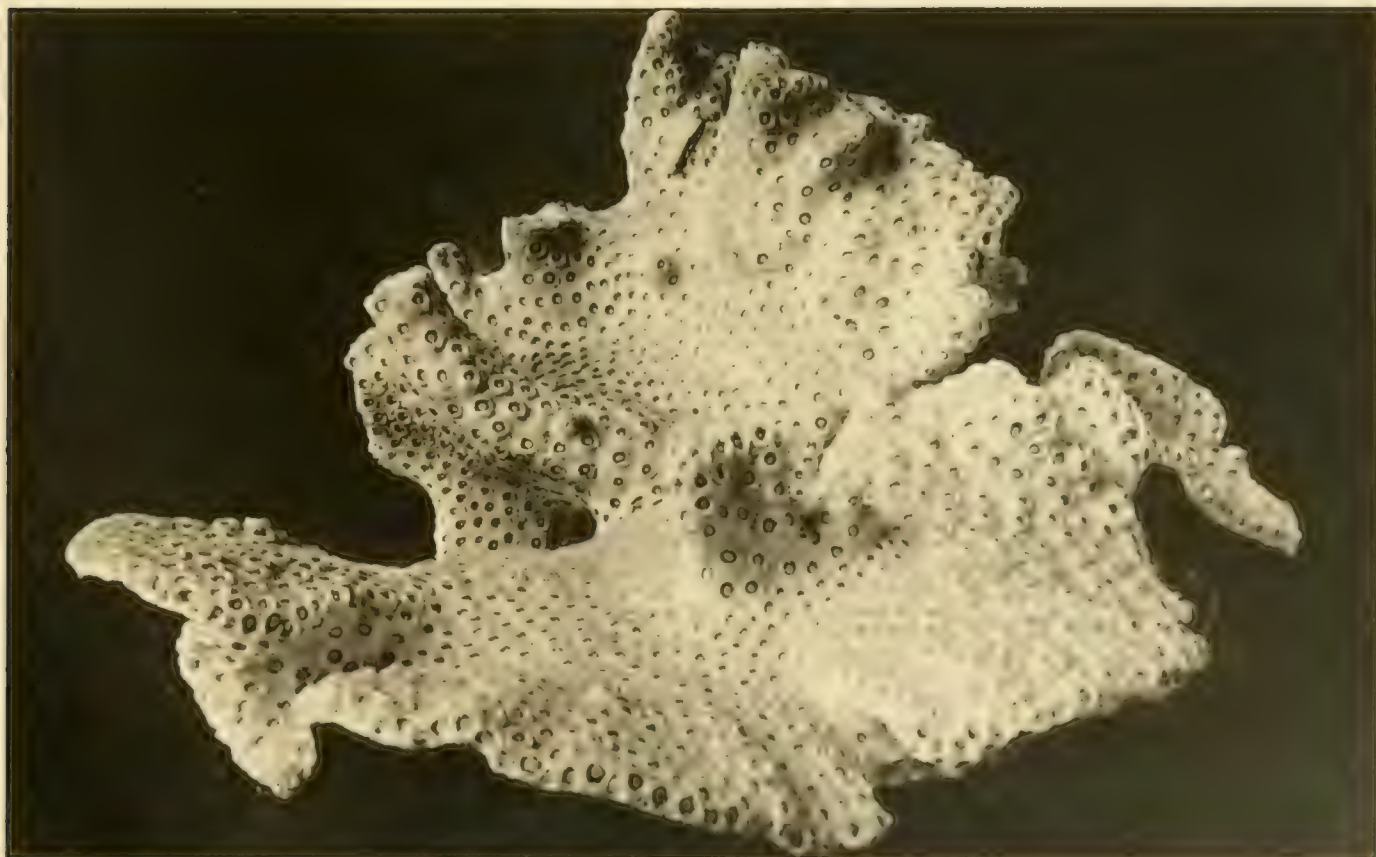
TURBINARIA PELTATA  $\times \frac{1}{2}$





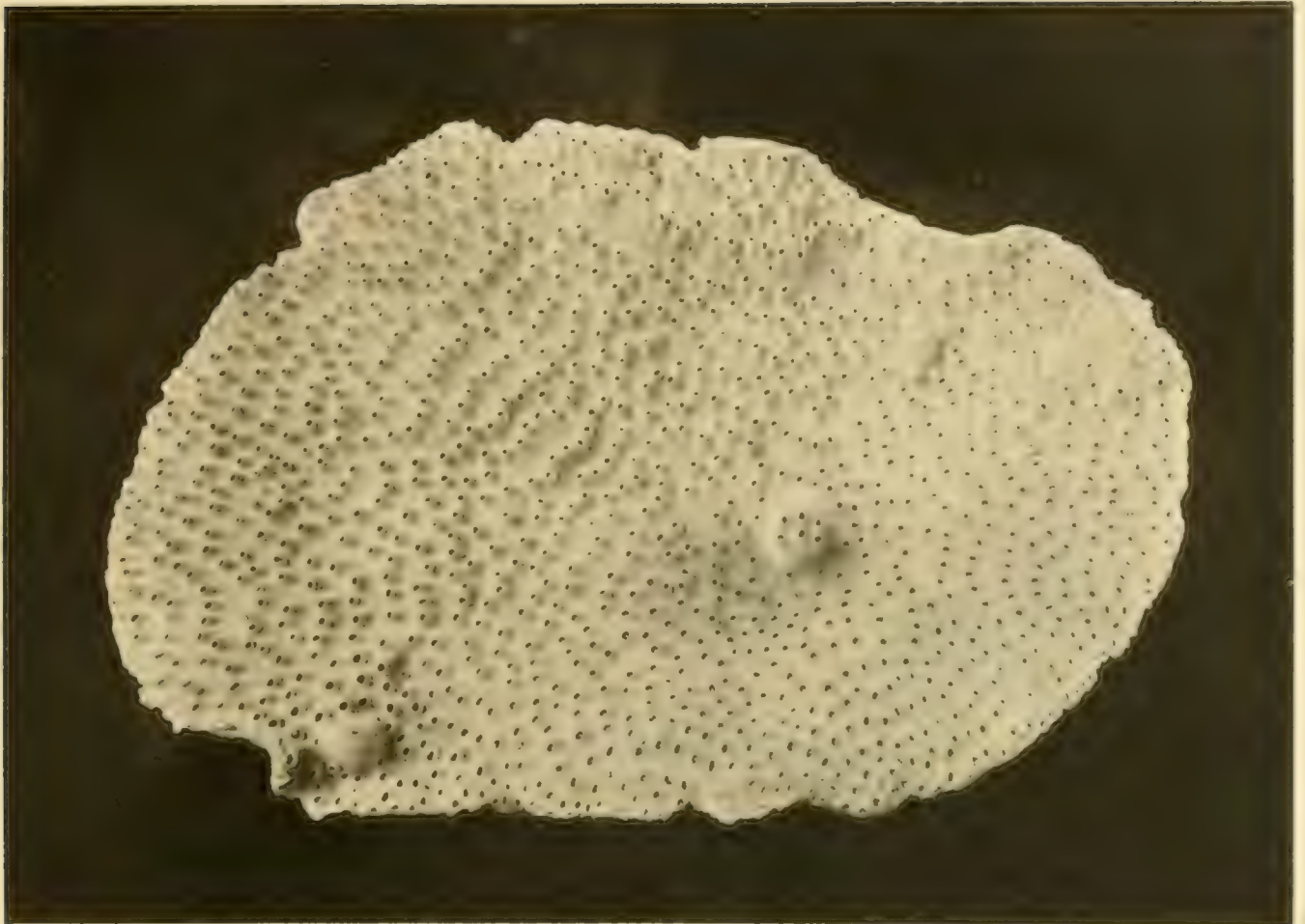


TURBINARIA PELTATA  $\times \frac{1}{2}$



TURBINARIA PATULA  $\times \frac{1}{2}$





TURBINARIA PATULA  $\times \frac{1}{2}$



TURBINARIA RADICALIS



TURBINARIA AGARICIA  $\times \frac{1}{2}$







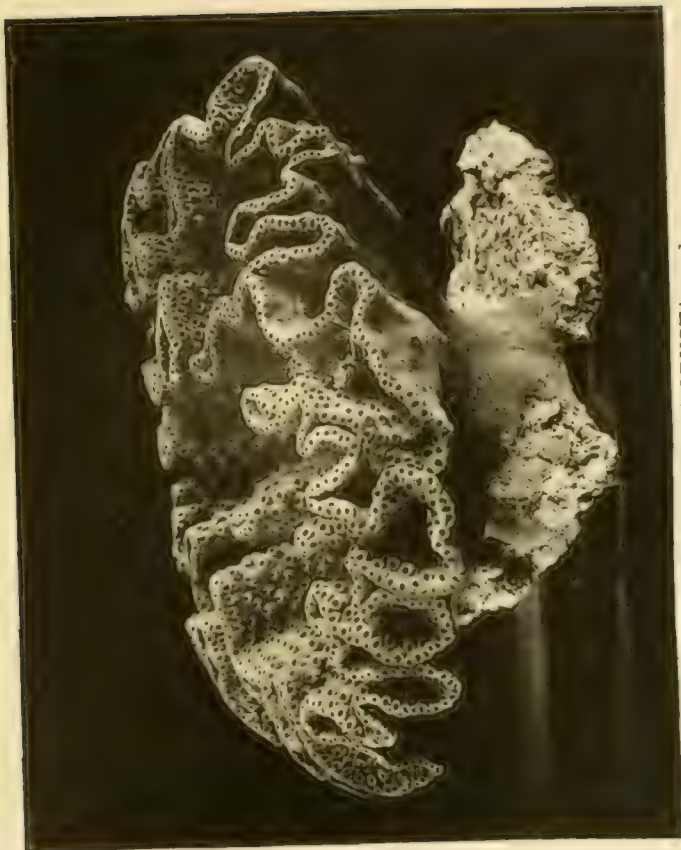




BRIT. MUS., MADREPOR. II.



TURBINARIA CALICULARIS  $\times \frac{1}{2}$



TURBINARIA ROBUSTA  $\times \frac{1}{2}$



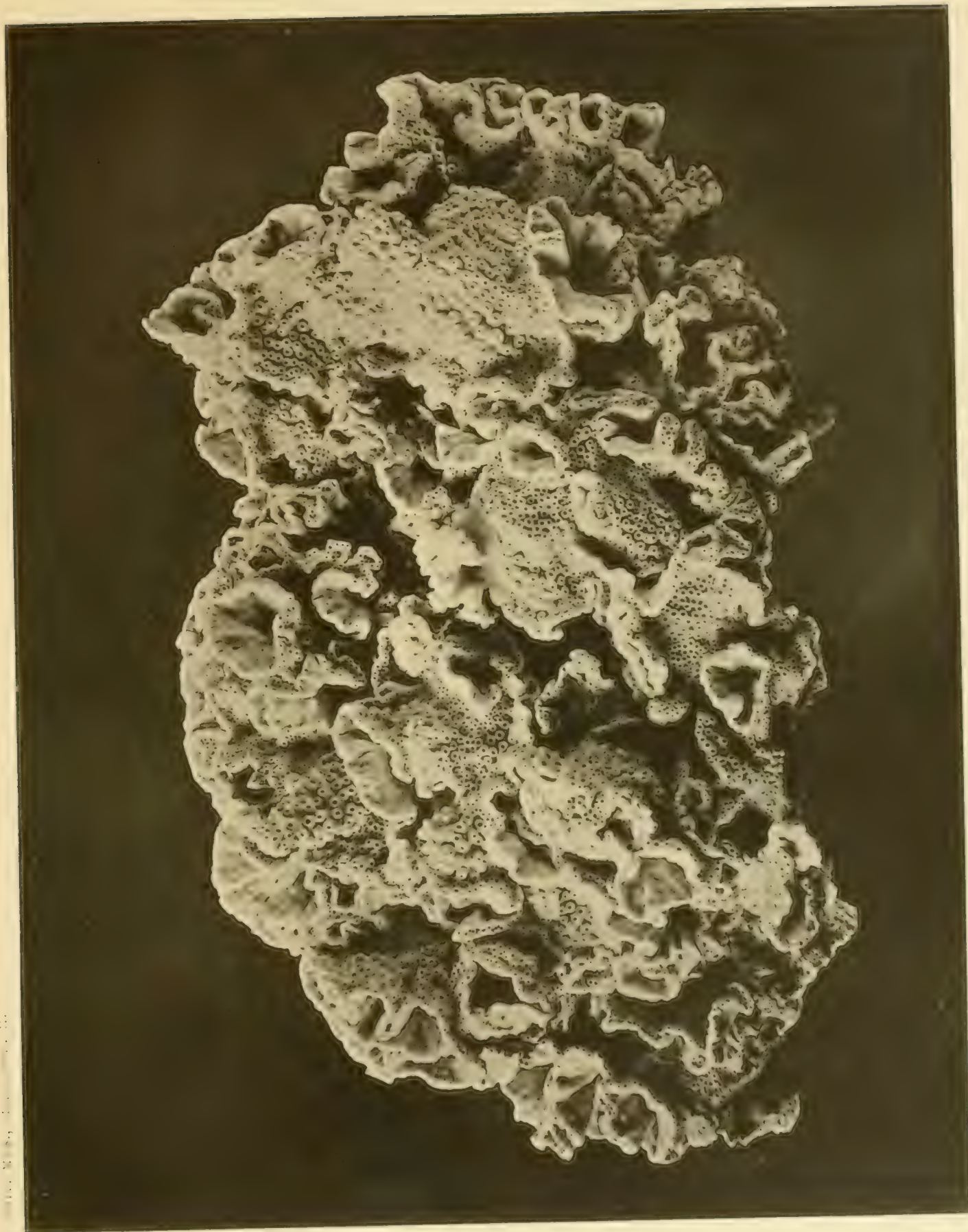
TURBINARIA VENUSTA  $\times \frac{1}{2}$



TURBINARIA VENUSTA  $\times \frac{1}{2}$







TURBINARIA IRREGULARIS x 1

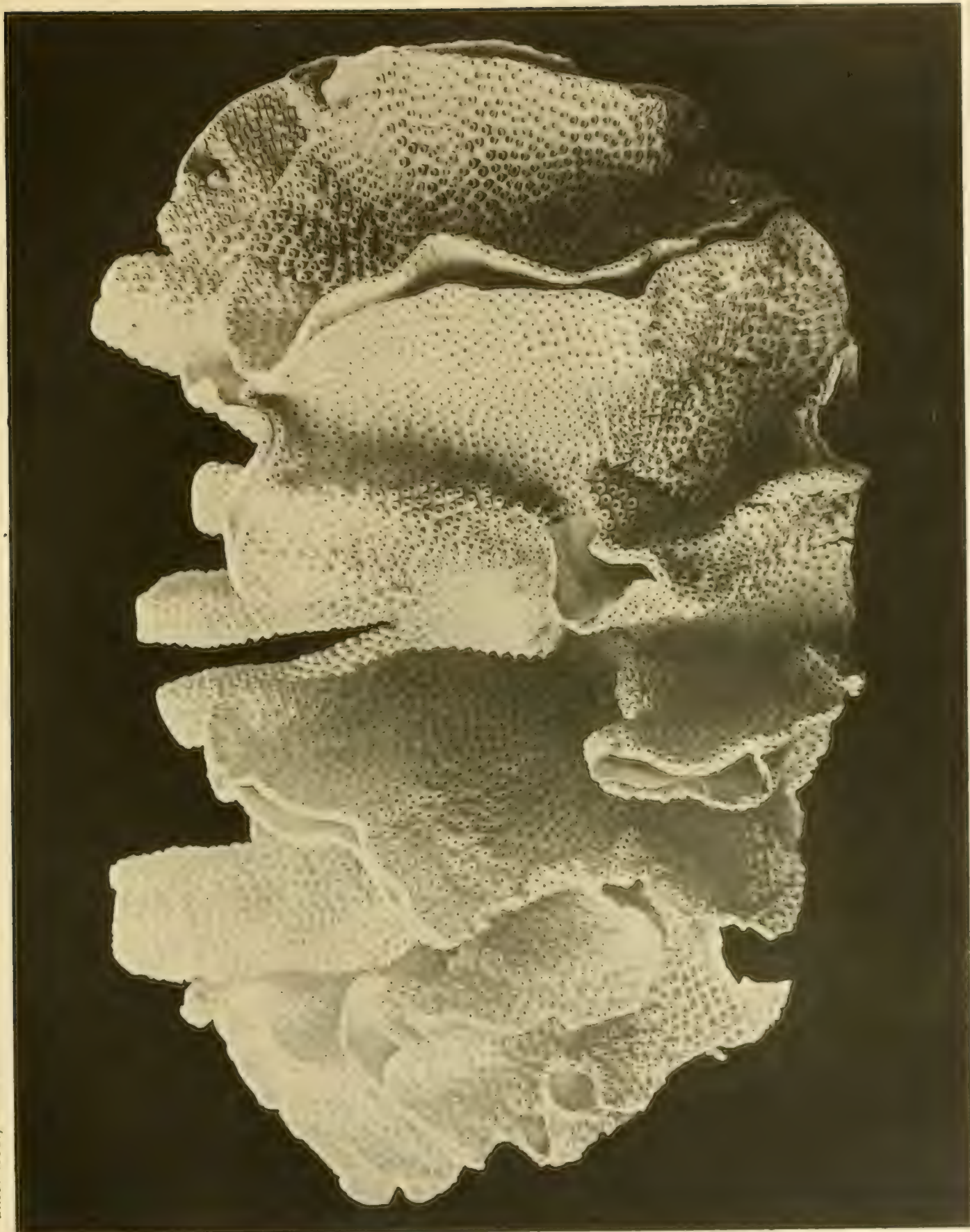


















TURBINARIA MAGNA  $\times 3$



TURBINARIA ASPERA  $\times 3$



TURBINARIA BRUEGGMANNI  $\times 4$



TURBINARIA MESENTERINA  $\times 3$







TURBINARIA LICHENOIDES x 1



TURBINARIA LICHENOIDES (upper surface)



TURBINARIA REPTANS x 1



TURBINARIA REPTANS (upper surface)



















TURBINARIA RUGOSA x 3





BRIT. MUS., MADREPOR, II.



TURBINARIA ELEGANS  $\times \frac{1}{2}$



TURBINARIA VELUTA  $\times \frac{1}{2}$



TURBINARIA STELLULATA  $\times \frac{1}{2}$



TURBINARIA GLOBULARIS  $\times \frac{1}{2}$

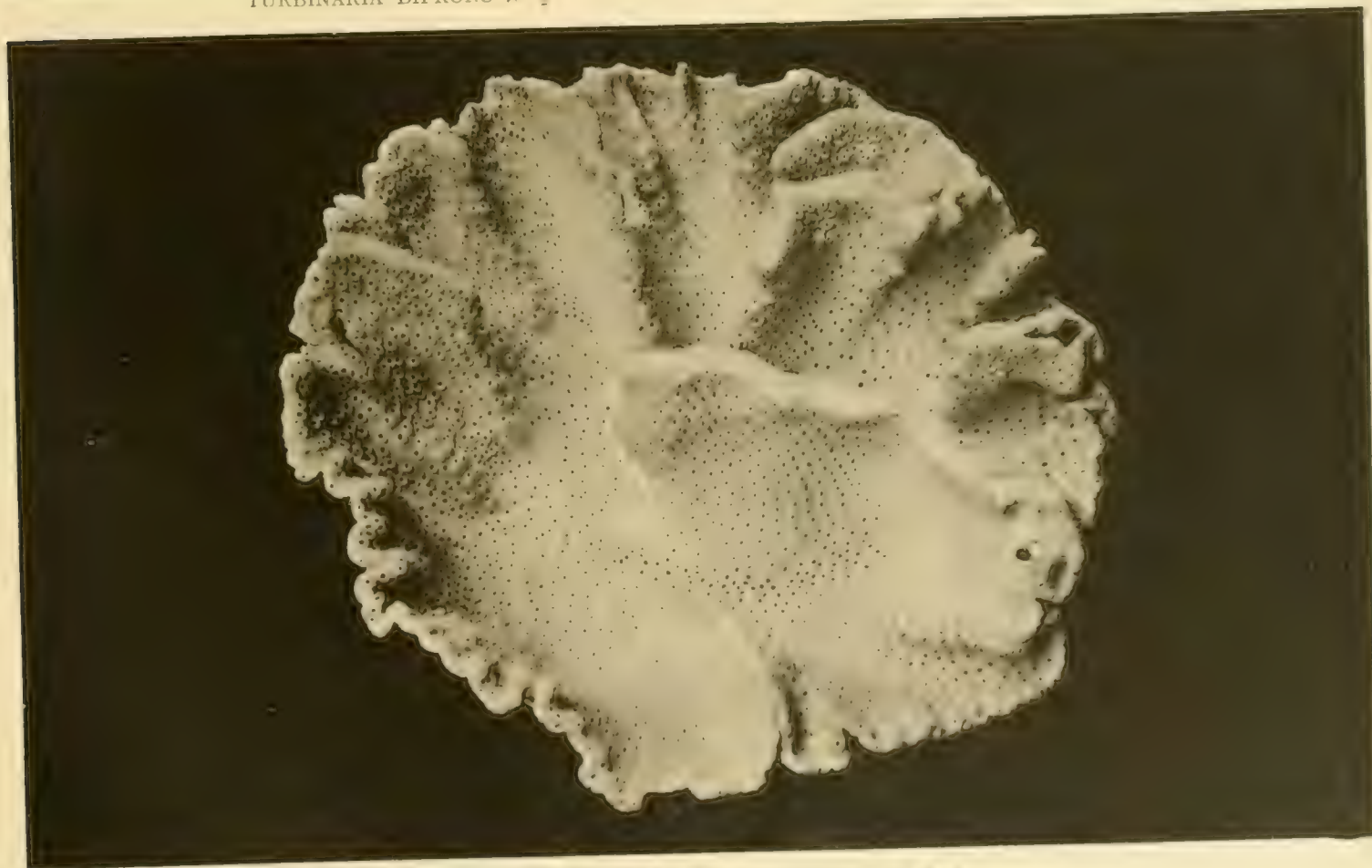




TURBINARIA BIFRONS × 1



TURBINARIA BIFRONS



TURBINARIA DENDROPHYLLA × 1

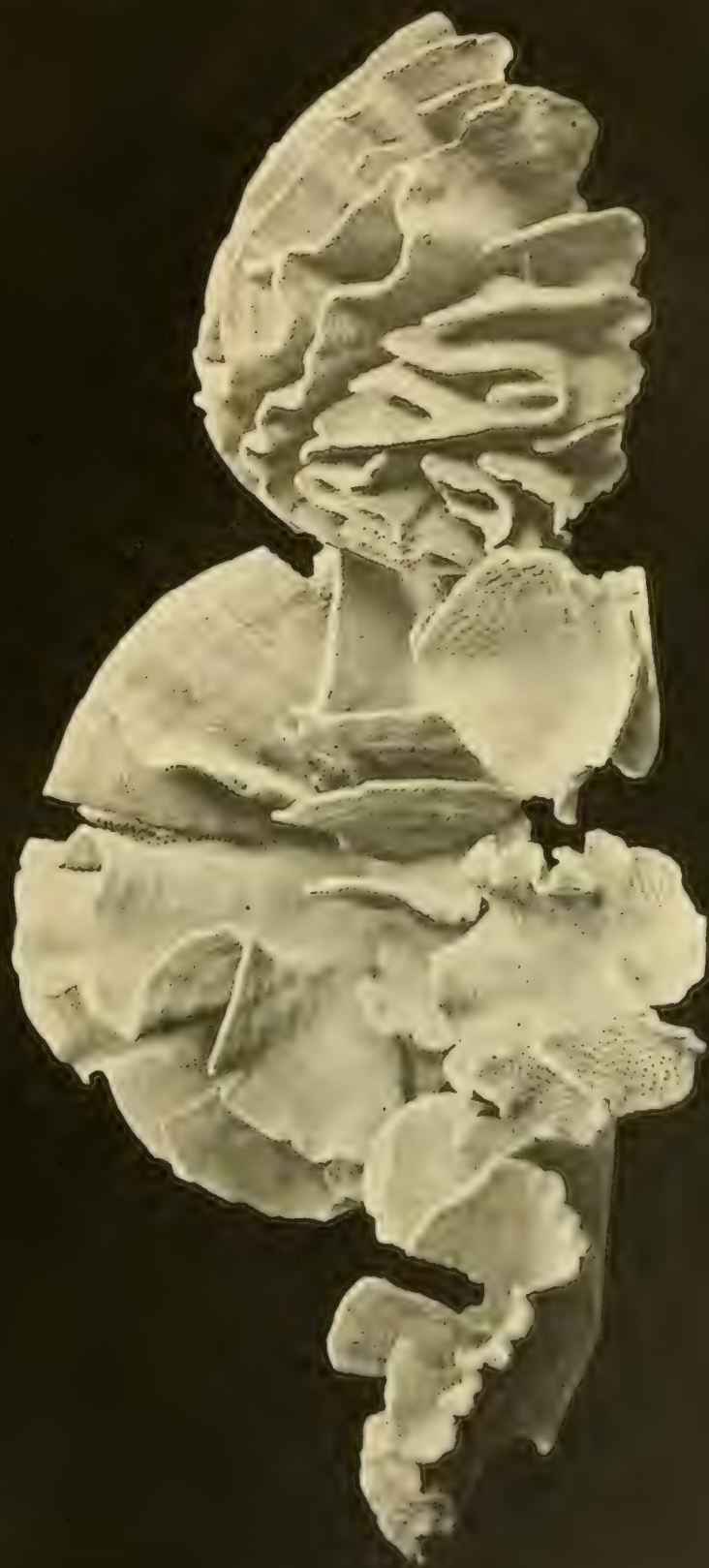




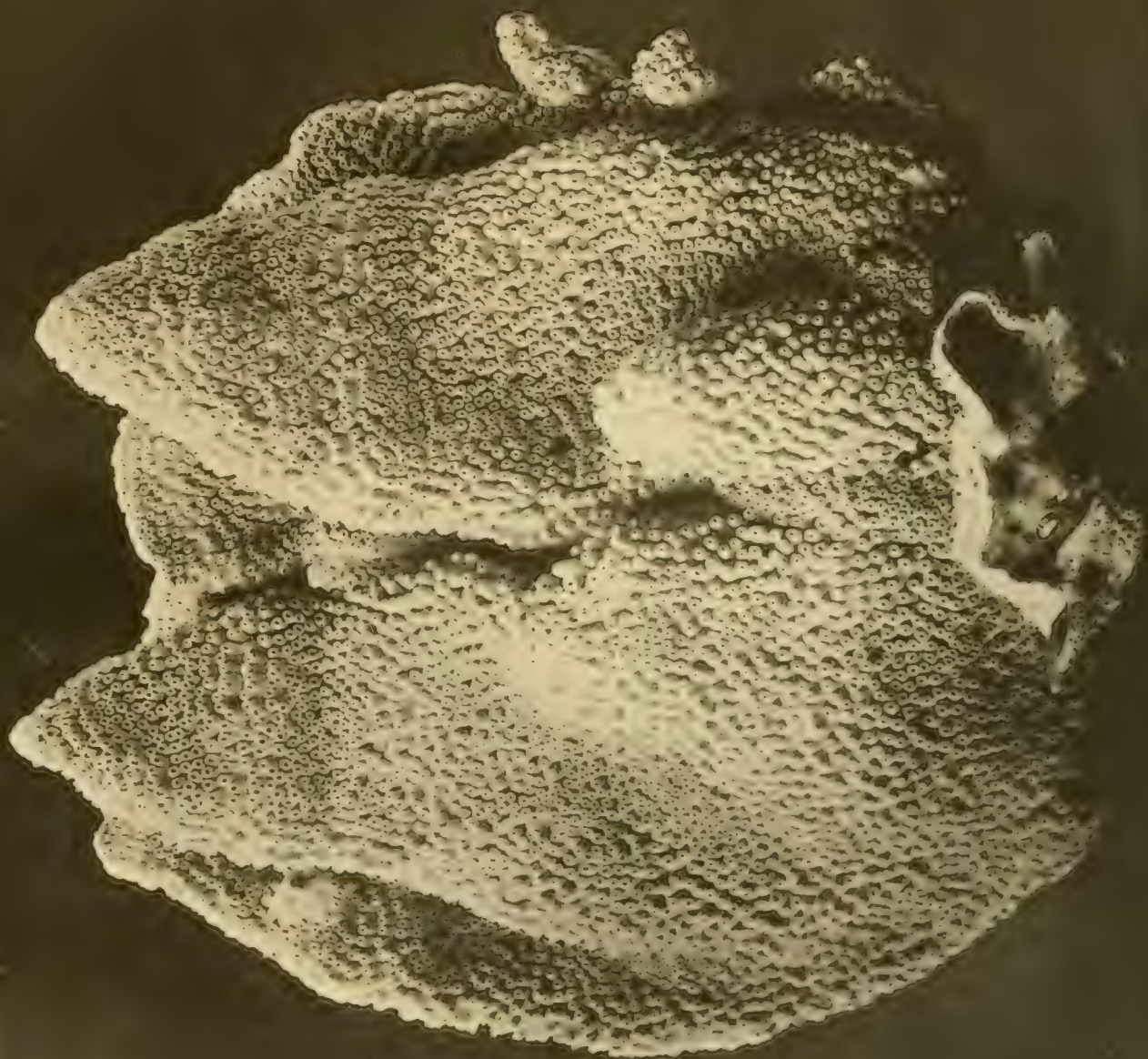














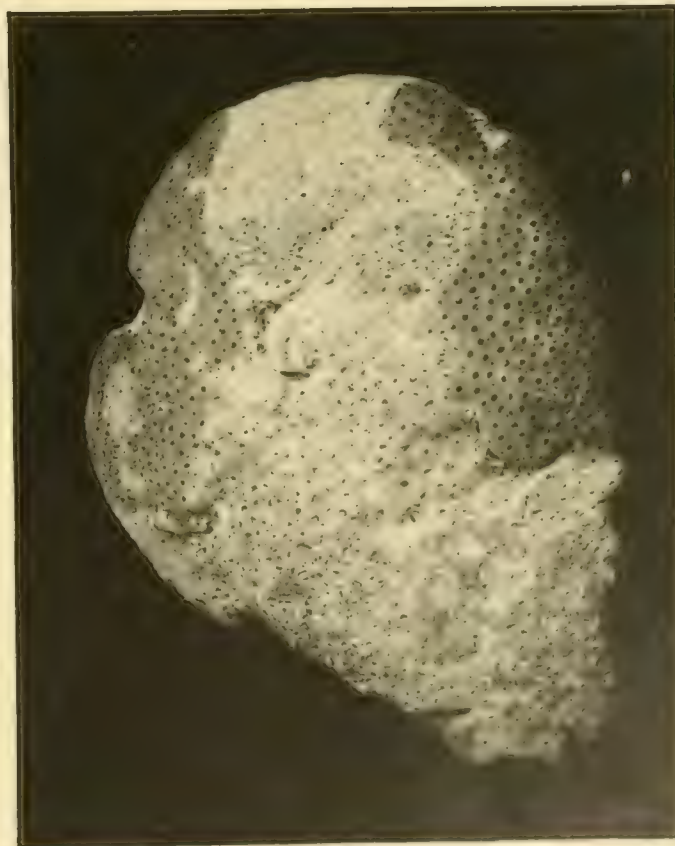




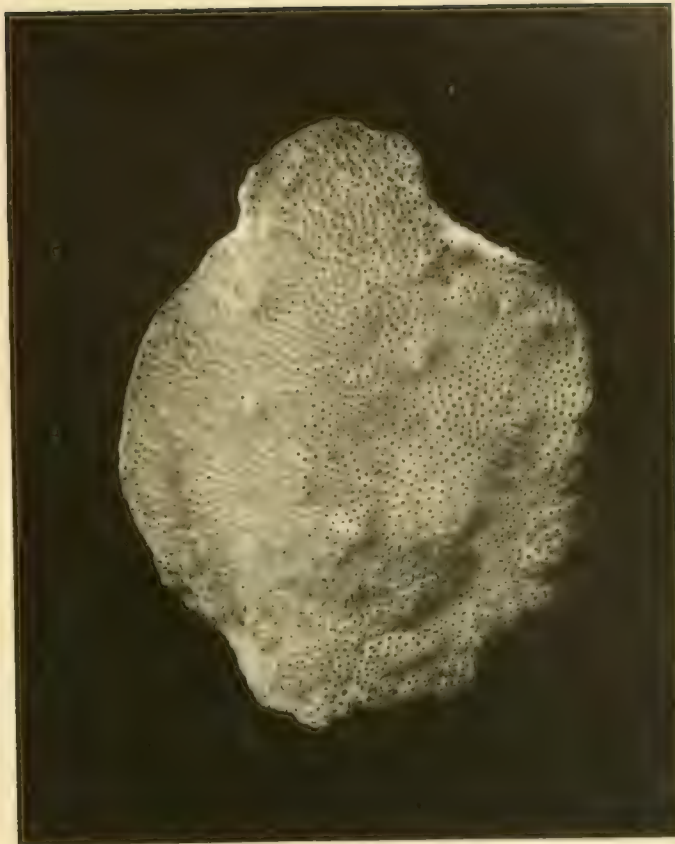
TURBINARIA SUBVERSA  $\times \frac{1}{3}$



ASTRÆOPORA EXPANSA  $\times \frac{1}{3}$



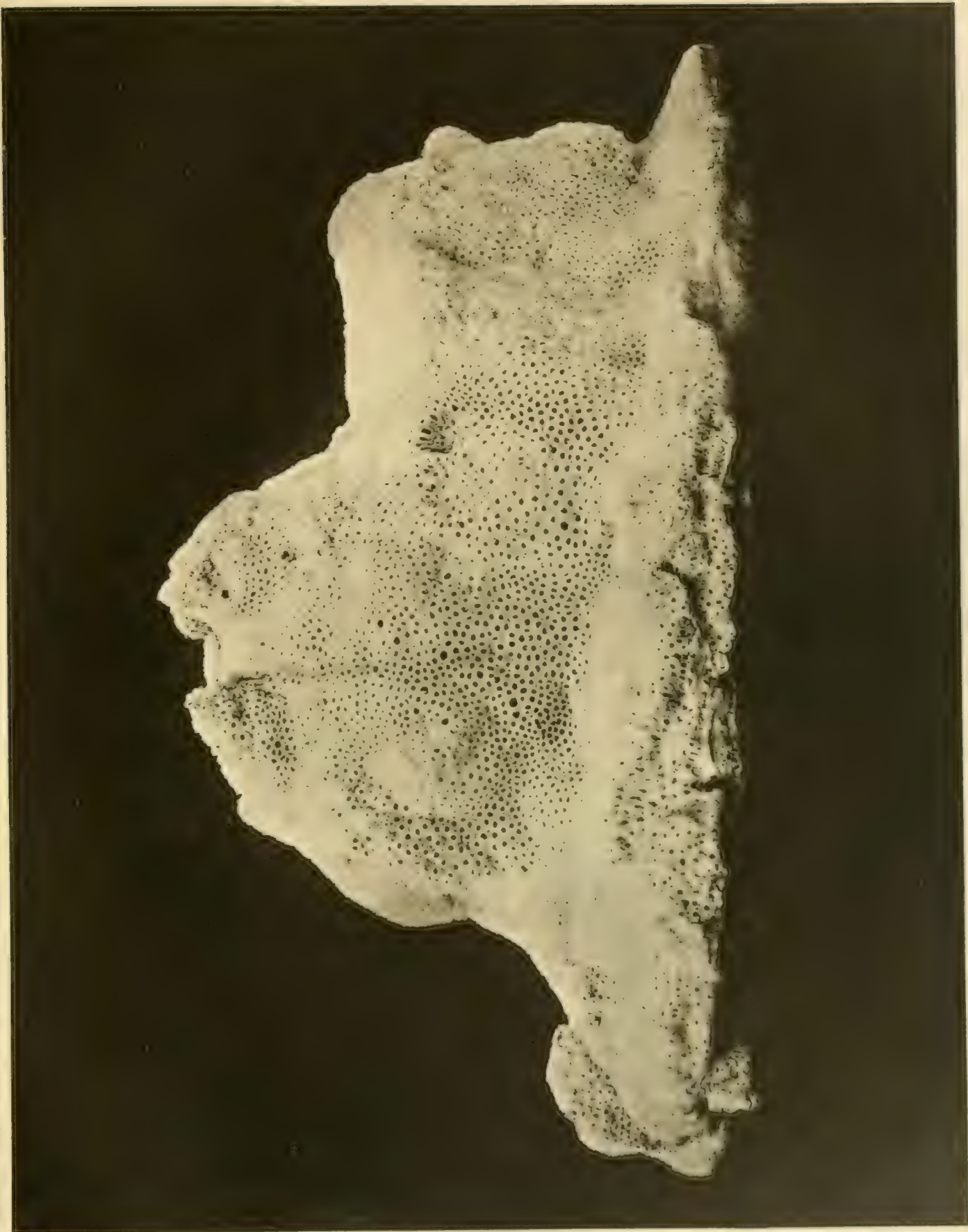
ASTRÆOPORA HORIZONTALIS  $\times \frac{1}{3}$



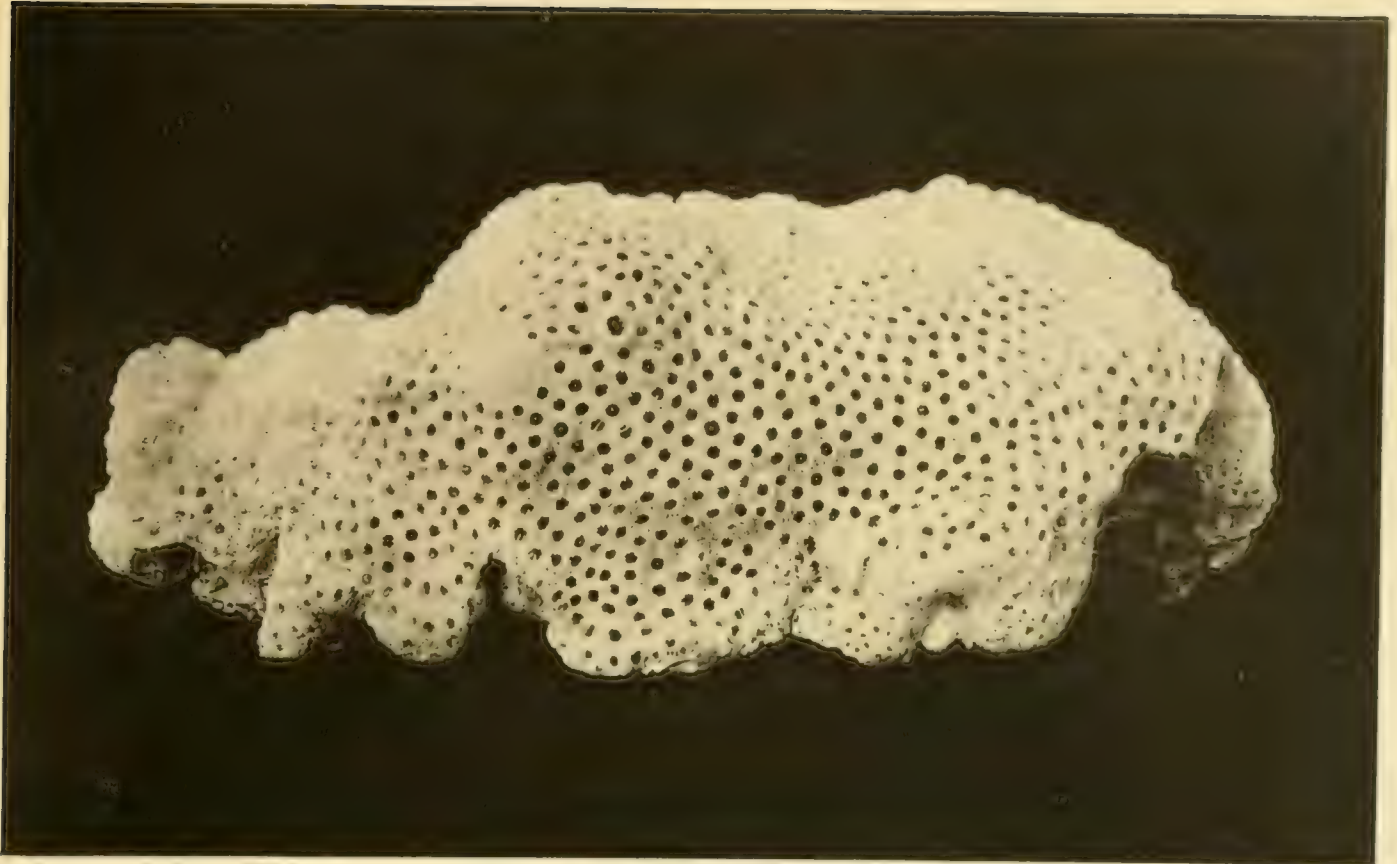
ASTRÆOPORA MYRIOPHTHALMA  $\times \frac{1}{3}$



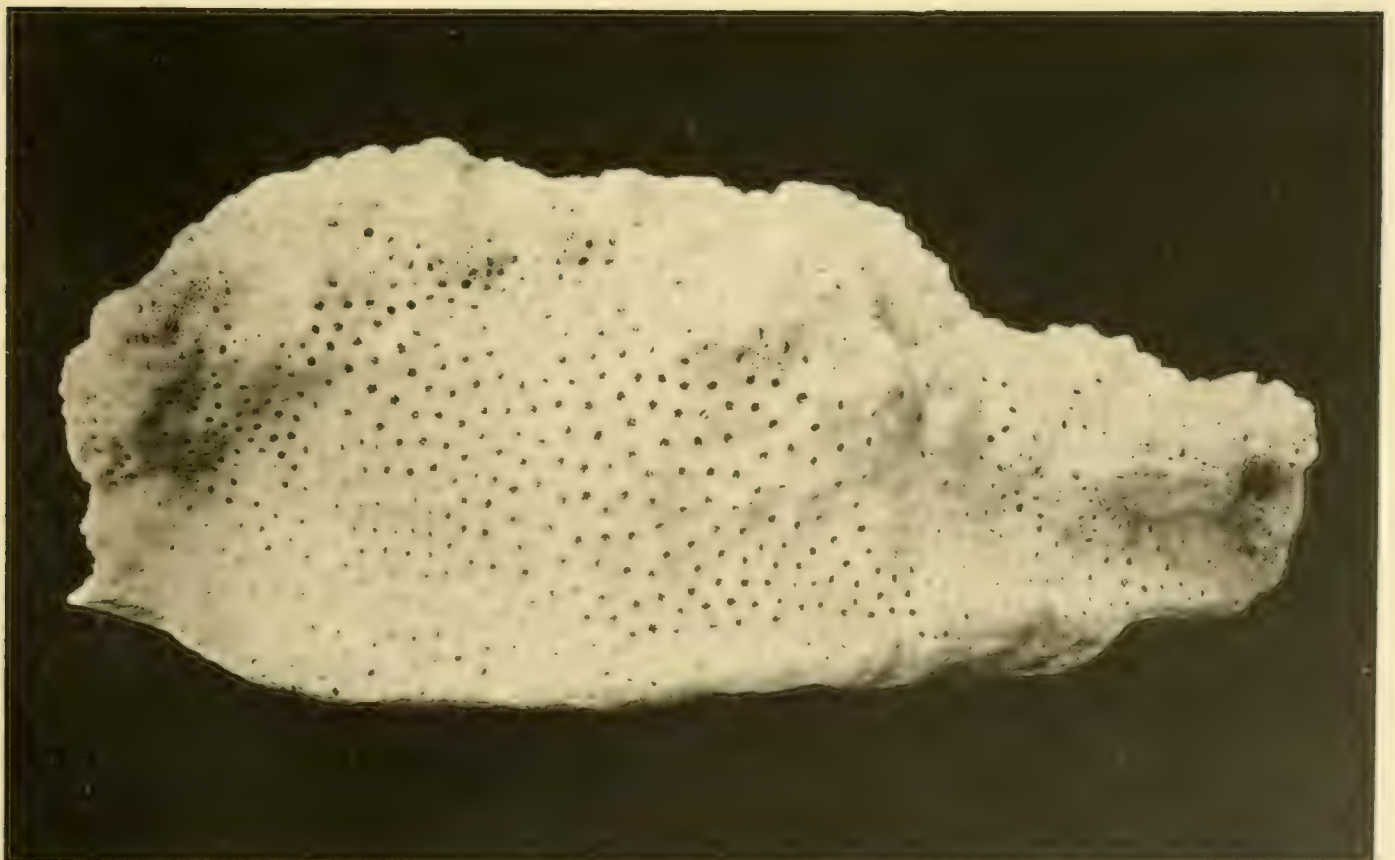








ASTREOPORA INCRUSTANS × 1



ASTREOPORA INCRUSTANS × 1













ASTRÆOPORA LISTERI  $\times \frac{1}{2}$



ASTRÆOPORA ARENARIA  $\times \frac{1}{2}$



ASTRÆOPORA GRACILIS  $\times \frac{1}{2}$



ASTRÆOPORA OCULATA





ASTRÆOPORA OVALIS



ASTRÆOPORA PUNCTIFERA  $\times \frac{1}{2}$



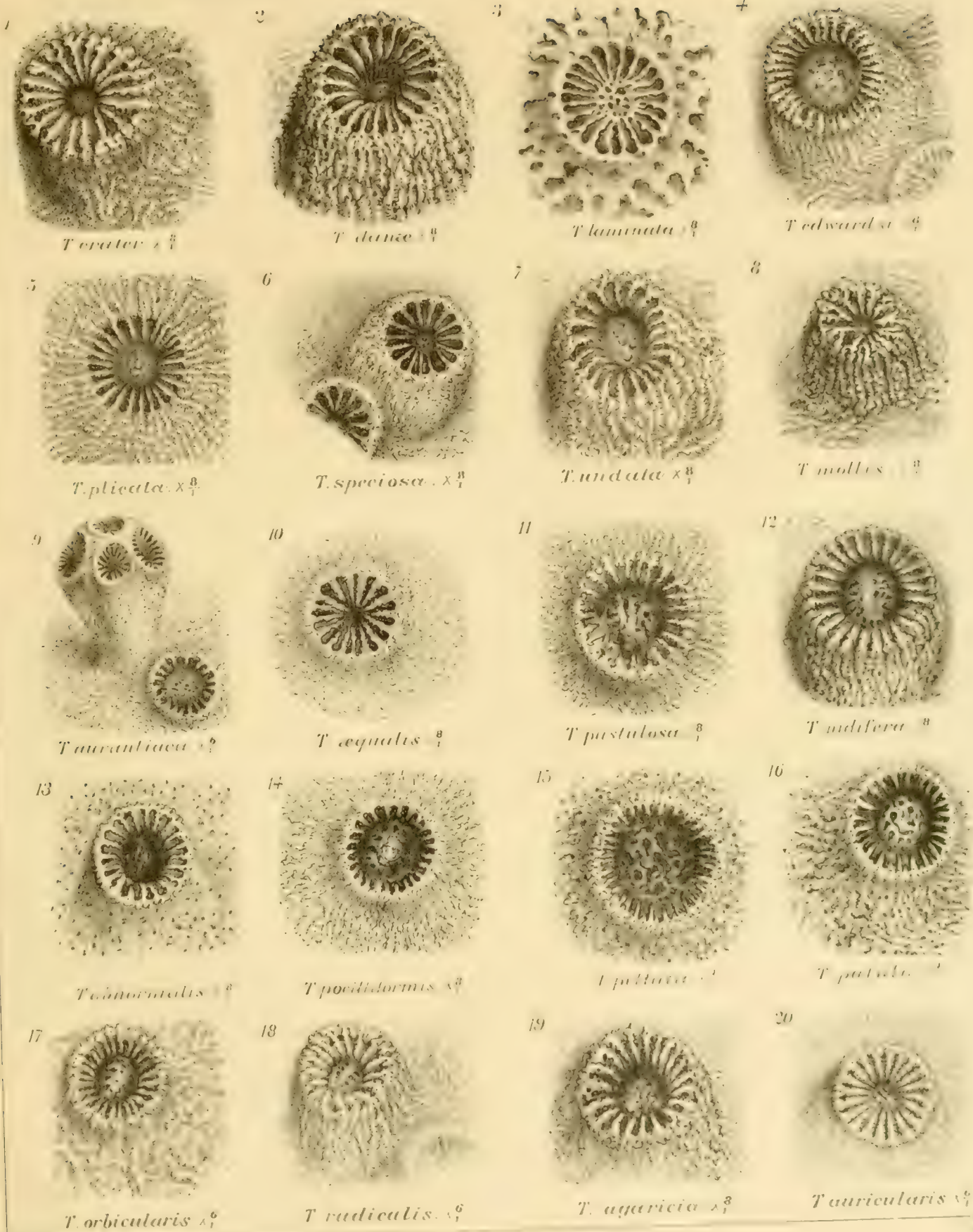
ASTRÆOPORA KINII  $\times \frac{1}{2}$



ASTRÆOPORA PROFUNDA  $\times \frac{1}{2}$





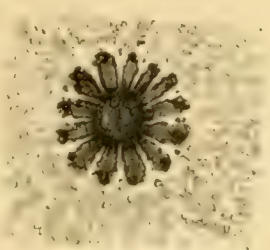


## TURBINARIA

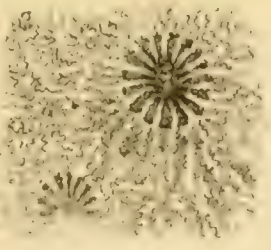




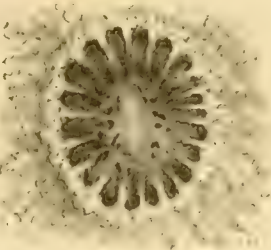
1

*T. calicularis* ×  $\frac{3}{4}$ 

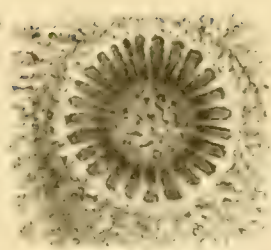
2

*T. porcellanea* ×  $\frac{3}{4}$ 

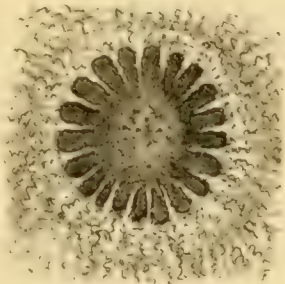
3

*T. magna* ×  $\frac{3}{4}$ 

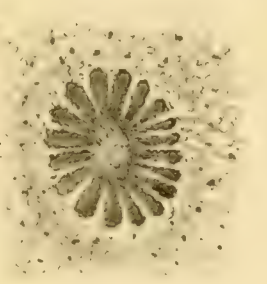
4

*T. irregularis* ×  $\frac{3}{4}$ 

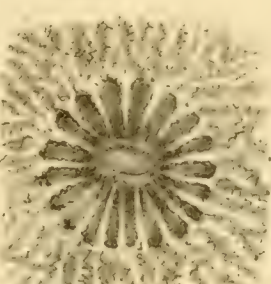
5

*T. robusta* ×  $\frac{3}{4}$ 

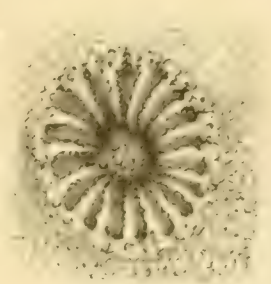
6

*T. pulcherrima* ×  $\frac{3}{4}$ 

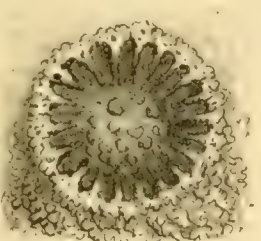
7

*T. tubulera* ×  $\frac{3}{4}$ 

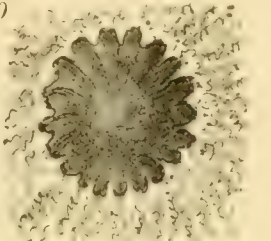
8

*T. venusta* ×  $\frac{3}{4}$ 

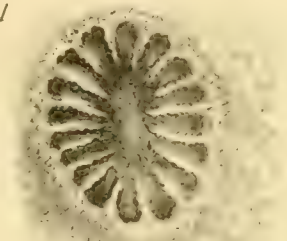
9

*T. aspera* ×  $\frac{3}{4}$ 

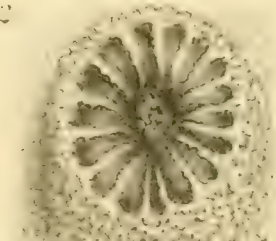
10

*T. moseleyana* ×  $\frac{3}{4}$ 

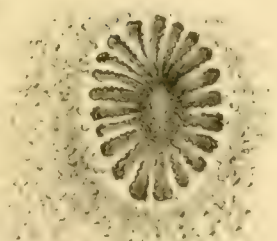
11

*T. lichenoides* ×  $\frac{3}{4}$ 

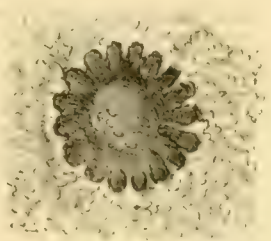
12

*T. reptans* ×  $\frac{3}{4}$ 

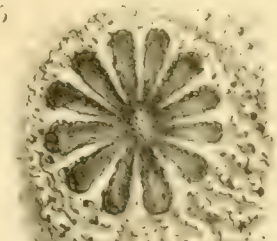
13

*T. bouquiemanni* ×  $\frac{3}{4}$ 

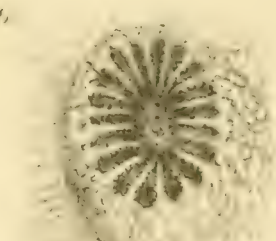
14

*T. reniformis* ×  $\frac{3}{4}$ 

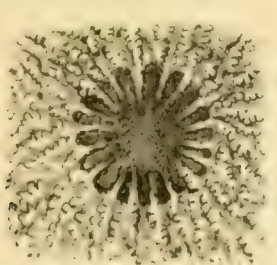
15

*T. foliosa* ×  $\frac{3}{4}$ 

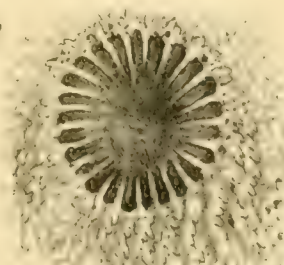
16

*T. muricea* ×  $\frac{3}{4}$ 

17

*T. crassa* ×  $\frac{3}{4}$ 

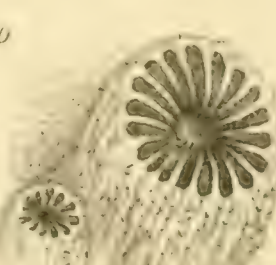
18

*T. elegans* ×  $\frac{3}{4}$ 

19

*T. velutina* ×  $\frac{3}{4}$ 

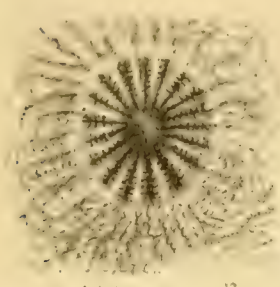
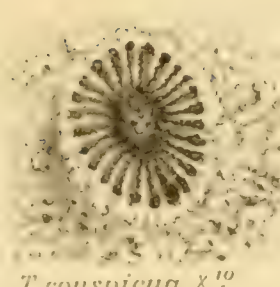
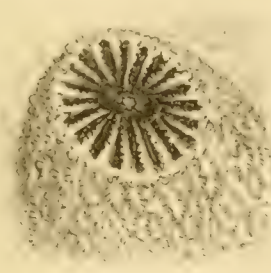
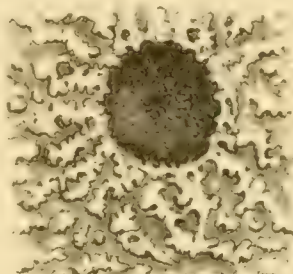
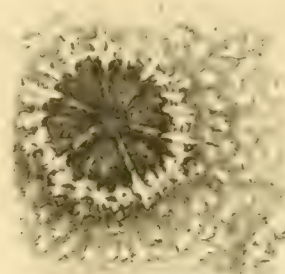
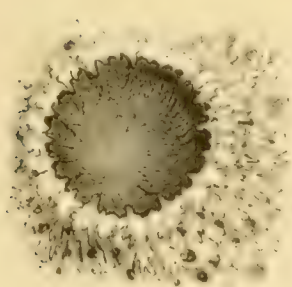
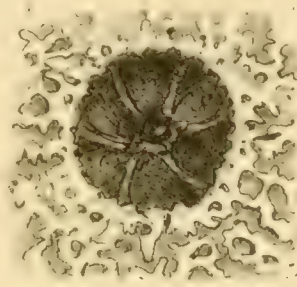
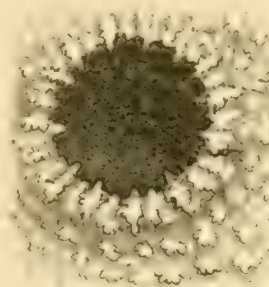
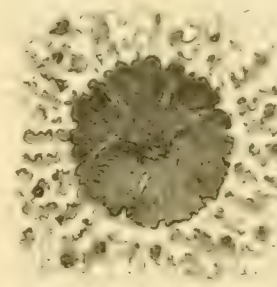
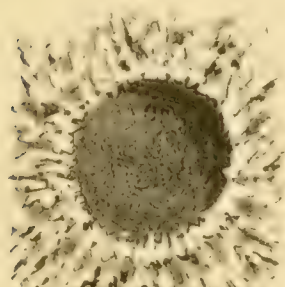
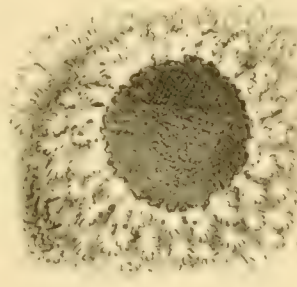
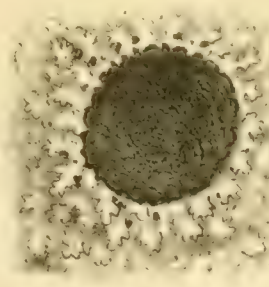
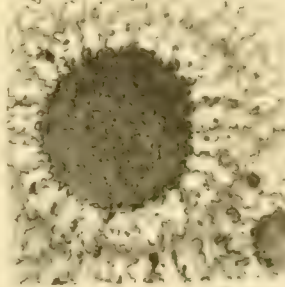
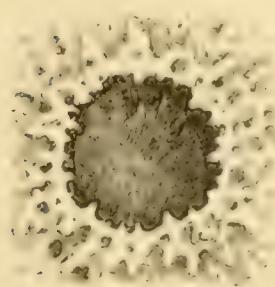
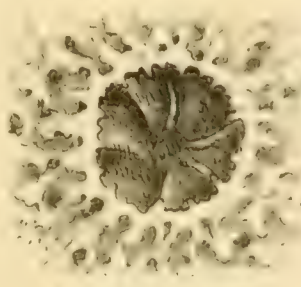
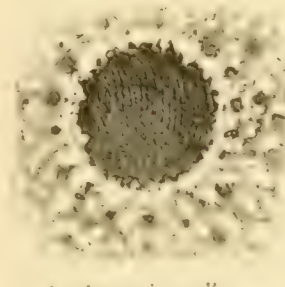
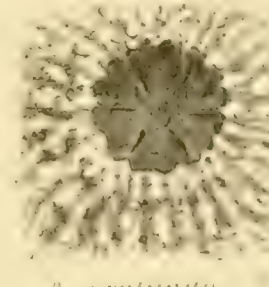
20

*T. globularis* ×  $\frac{3}{4}$ 

## TURBINARIA





*T. bifrons*  $\times \frac{12}{1}$ *T. dendrophyllia*  $\times \frac{8}{1}$ *T. conspicua*  $\times \frac{10}{1}$ *T. gracilis*  $\times \frac{7}{1}$ *T. contorta*  $\times \frac{8}{1}$ *T. subversa*  $\times \frac{8}{1}$ *A. expansa*  $\times \frac{8}{1}$ *A. horizontalis*  $\times \frac{8}{1}$ *A. myriophthalma*  $\times \frac{8}{1}$ *A. incrustans*  $\times \frac{8}{1}$ *A. arenaria*  $\times \frac{8}{1}$ *A. listeri*  $\times \frac{7}{1}$ *A. umbrata*  $\times \frac{8}{1}$ *A. gracilis*  $\times \frac{8}{1}$ *A. chuenbergi*  $\times \frac{8}{1}$ *A. ocellata*  $\times \frac{8}{1}$ *A. ovalis*  $\times \frac{8}{1}$ *A. punctifera*  $\times \frac{12}{1}$ *A. kenti*  $\times \frac{8}{1}$ *A. profunda*

## TURBINARIA AND ASTRÆOPORA















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